10.0 INCIDENTAL TAKE STATEMENT

10.1 INTRODUCTION

Section 9 of the ESA and Federal regulations pursuant to Section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct." Incidental take is defined as "take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity." Under the terms of Section 7(b)(4) and Section 7(a)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the ESA, provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described in this section are nondiscretionary and must be undertaken by the Corps, BPA, and BOR. The Action Agencies have a continuing duty to regulate the activities covered by this incidental take statement. If the Action Agencies fail to assume and implement the terms and conditions of this incidental take statement, the protective coverage of Section 7(a)(2) may lapse. To monitor the effect of incidental take, the Action Agencies must report the progress of the action and its effect on each listed species to NMFS, as specified in this incidental take statement [50 CFR Section 402.14(i)(3)].

NMFS has developed the following incidental take statement based on the premise that the RPA described in Section 9 of the biological opinion will be implemented.

10.2 AMOUNT OR EXTENT OF ANTICIPATED TAKE

10.2.1 Incidental Take Associated with Operation of FCRPS

The level of incidental take expected to occur as a result of the RPA will vary annually as the RPA measures are implemented. Initially, the expected take will be approximately equal to the juvenile and adult mortality rates associated with the proposed action, as estimated in Sections 6.2 and 6.3. Once the RPA measures are completely implemented, no later than 2010, the expected take will be reduced to a level that is approximately equal to the juvenile and adult mortality rates associated with the RPA, as estimated in Section 9.7. During the intervening period, the incidental take is expected to decrease on a schedule that cannot be precisely determined at this time. The estimate of incidental take will, therefore, be updated before March 1 of each year. This update will be based on the preceding year's annual report, which will describe those elements of the RPA that were completed in the preceding year, those anticipated to be implemented during the upcoming year, and research to further characterize the effects of implementing those elements on survival of listed ESUs.

Tables 10.1-1 and 10.1-2 identify the expected incidental take resulting from the RPA during 2001 and 2010 for juvenile and adult salmonids, respectively. The take estimates include mortality expected to occur as a result of passage through the mainstem FCRPS projects only. The juvenile take represents means of a range of annual estimates and, for some ESUs, a range of differential delayed mortality estimates. Averages included 1994 through 1999 for spring chinook and steelhead and 1995 through 1999 for SR fall chinook. The SR spring/summer chinook D (delayed mortality) estimate ranged from 0.63 to 0.73, the SR fall chinook D estimate was 0.24, and the SR steelhead D estimate ranged from 0.52 to 0.56.

Quantitative estimates of take are not possible for the spawning and incubation stages of SR fall chinook, LCR chinook salmon, and CR chum salmon. The incidental take of these species during the spawning and incubation life stages will be considered authorized if flow operations are implemented as described in Section 9.6.1.2. Take of juvenile sockeye salmon will be considered authorized as long as the allowable take of juvenile SR spring/summer chinook and SR steelhead is not exceeded, due to the similarity in timing and similar size of each ESU.

10.2.2 Incidental Take Associated with Offsite Mitigation

This biological opinion does not authorize incidental take associated with any projects related to offsite mitigation. It is anticipated that the Action Agencies will seek authorization for any take associated with offsite mitigation projects through separate consultations with NMFS, once details of the proposed actions are determined.

Table 10.1-1 Estimates of incidental take of juvenile salmonids resulting from the RPA during 2001 and 2010.

ESU	Estimated Total System Juvenile Mortality (%)	
	2001	2010
Chinook		
SR spring/summer[1]	43	42
SR fall[2]	88	87
UCR spring [3]	43	34
LCR spring[4]	13	9
LCR fall[4]	28	22
UWR	N/A	N/A
Steelhead		
SR[5]	52	49
UCR[6]	41	32
MCR[7]	41	32
LCR[8]	13	9
UWR	N/A	N/A
Sockeye		
SR[9]	N/A	N/A
Chum		
CR[10]	28	22

Note: Estimates of mean incidental take resulting from RPA in 2001 and 2010. Estimates of take during intervening years will be updated annually. N/A = not applicable (for ESUs that do not pass through the hydrosystem). Estimates for ESUs with populations that pass variable numbers of dams are for maximum number of dams passed.

1 Represents survival of transported and nontransported smolts, including NMFS' (2000e) estimate of differential delayed mortality. Take of inriver migrants is estimated as 59% in 2001 and 50% in 2010. For comparison, estimate of natural mortality is 15% (Appendix A).

2 Represents survival of transported and non-transported smolts, including PATH 24% estimated of differential delayed mortality. Take of inriver migrants is estimated as 90% in 2001 and 86% in 2010. For comparison, estimate of natural mortality is 32% to 77% (Appendix A).

3 For comparison, estimate of natural mortality is 9% (Appendix A).

4 For comparison, estimate of natural mortality is 2% (Appendix A).

5 Represents survival of transported and nontransported smolts including NMFS' (2000e) estimates of differential delayed mortality. Take of inriver migrants is estimated as 59% in 2001 and 49% in 2010. For comparison, estimate of natural mortality is 16% (Appendix A).

6 For comparison, estimate of natural mortality is 9% (Appendix A).

7 For comparison, estimate of natural mortality is 9% (Appendix A).

8 For comparison, estimate of natural mortality is 1% (Appendix A).

9 A quantitative estimate is not available for this ESU. SR sockeye take is authorized as long as allowable take of SR spring/summer chinook and SR steelhead is not exceeded.

10 Based on LCR fall chinook survival estimates. No estimate of natural survival rate is available for comparison.

Table 10.1-2. Estimates of incidental take of adult salmonids expected to result from RPA during 2001 and 2010. Estimates of adult take will be updated annually during the intervening years. N/A = not applicable (i.e., for ESUs that do not pass FCRPS projects). Estimates for ESUs with subbasin populations that pass different numbers of dams are for the maximum number of dams passed.

ESU	Estimated Adult Mortality (%)	
	2001	2010
Chinook		
SR spring/ summer	18	15
SR fall	29	26
UCR spring	9	8
LCR spring	3	2
LCR fall	4	4
UWR	N/A	N/A
Steelhead		
SR	23	20
UCR	12	11
MCR	12	11
LCR	3	3
UWR	N/A	N/A
Sockeye		
SR	14	11
Chum		
CR	4	4

10.3 EFFECT OF THE TAKE

In the biological opinion, NMFS determined that this level of anticipated take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

The overall incidental take of ESA-listed juvenile and adult anadromous fish species under the proposed action is described in Tables 9.7.1 and 9.7.2, respectively. The take of listed species resulting from the research and monitoring activities described in Tables 9.7.1.1 and 9.7.1.2 is incorporated into the earlier tables and is not in addition to those estimates. A proportion of the overall authorized take is partitioned among the specifically numbered research projects described in Section 9.6.5.5.

10.4 REASONABLE AND PRUDENT MEASURES

10.4.1 Monitor Incidental Take

The Action Agencies will monitor the level of incidental take associated with the RPA and report the results to NMFS in a timely manner.

10.4.2 Reduce Incidental Take by Improving Juvenile and Adult Passage Survival

The Action Agencies will reduce the level of incidental take by implementing measures to further improve survival of juveniles and adults, in addition to measures required by the RPA. NMFS has determined that the additional measures specified in Section 10.5 constitute only minor changes to the RPA.

10.5 TERMS AND CONDITIONS

10.5.1 Terms and Conditions Related to Monitoring Take

10.5.1.1 Evaluate Reach Survivals

The Action Agencies will estimate dam passage and inriver survival of both juvenile and adult migrating salmonids. Using PIT-tags, radio tags, sonic tags, or other developing technology, the Action Agencies will measure the survival of juvenile fish migrating through the FCRPS. Using radio and PIT tags and additional techniques, they will also measure the survival and reproductive success (arrival on the spawning grounds, successful spawning behavior, and successful gamete production) of adult salmonids migrating through the FCRPS. The primary focus of the current PIT-tag monitoring program is on juvenile inriver survival and return rates. However, as adult PIT-tag detection facilities are developed and installed, they will be used to measure adult passage survival on a per-project basis for fish with known origins and passage histories. Until then, a portion of the adult salmonid population will be radio-tagged, and their migration behavior and survival will be monitored as they migrate upstream through the FCRPS.

The Action Agencies, in coordination with NMFS through the annual planning process, will continue to provide funding for monitoring wild juvenile fall chinook survival, growth, and other early life attributes. Knowledge of wild fish early life attributes is critical as a baseline comparison for studies involving juvenile hatchery fall chinook used as surrogates for wild fish. Also, supplementation of juvenile fall chinook above Lower Granite Dam is resulting in increased parr densities. At some point, decreased growth may occur, affecting the survival of wild fish.

The Action Agencies will continue to provide funding for required monitoring of juvenile fish passage at all dams with bypass systems. Facilities with PIT-tag detection capability at selected FCRPS projects will be provided for this purpose. In addition, BPA is responsible for funding the smolt monitoring program coordinated and implemented by the Fish Passage Center, and the Corps is responsible for funding sampling relative to the juvenile fish transportation program and facility operations. To reduce juvenile fish handling and staffing requirements, multiple data sets are collected from sampled fish by onsite fishery agency personnel. For example, the Corps requires collection of fish condition information (injury, descaling, length, weight, etc.) to detect juvenile fish passage facility problems that can descale, injure, or kill fish. The Corps also needs information regarding the numbers and weights of fish collected and the species composition for holding and loading purposes at the collector dams. This sampling effort also meets the requirements of approved monitoring programs (smolt monitoring, GBT sampling) and research (AFEP, NWPPC's Fish and Wildlife Program), as well as new research required by this biological opinion). Given the multiple tasks accomplished under the program, the Action Agencies involved should share the cost of the program. Sampled juvenile fish handling at the projects should remain the responsibility of fishery agency personnel.

10.5.1.2 Monitor Smolt-to-Adult Returns

The Corps and BPA, in coordination with NMFS through the annual planning process, will evaluate transport-to-inriver return ratios for wild SR yearling chinook salmon and steelhead. In addition, the Corps and BPA will also evaluate effects of transportation of summer-migrating, subyearling SR chinook salmon.

Currently, the only way to conduct this research on spring-migrating fish is to mark and release wild fish at Lower Granite Dam, collect some for transport at Little Goose Dam, and allow others to continue their migration inriver. This design should continue until wild SR anadromous salmonids are abundant enough to conduct studies by PIT-tagging wild fish in natal areas above the lower Snake River dams. If the decision for the long-term operation of FCRPS projects on the lower Snake River includes continued reliance on transportation, the Corps and BPA will continue transport survival studies for spring and summer migrants passing Lower Granite Dam in future years.

Future research to evaluate the smolt-to-adult survival of subyearling fall chinook transported from Lower Granite versus the survival of marked study fish left to migrate in river will require adequate numbers of representative test fish (e.g., Lyons Ferry hatchery stock) and also may require special spill operations at one or more of the four collector dams.

10.5.1.3 Monitor Post-transport and Post-bypass Delayed Mortality

The Corps and BPA, in coordination with NMFS through the annual planning process, will include an evaluation of D of transported fish relative to inriver migrating juvenile anadromous salmonids during all transport evaluations.

Considerable uncertainty exists concerning the levels of differential post-Bonneville Dam mortality of transported and nontransported fish. Evaluations of post-transport and post-bypass delayed mortality should receive high priority. Determining how much transportation mitigates for the loss of juvenile anadromous salmonids during passage through the hydrosystem will be given the highest priority.

10.5.1.4 Monitor Juvenile Fish Passage at Dams

The Action Agencies will continue to provide funding for required monitoring of juvenile fish passage at all dams with bypass systems. Facilities with PIT-tag detection capability at selected FCRPS projects will be provided for this purpose. In addition, BPA is responsible for funding the smolt monitoring program coordinated and implemented by the Fish Passage Center, and the Corps is responsible for funding sampling relative to the juvenile fish transportation program and facility operations. To reduce juvenile fish handling and staffing requirements, multiple data sets are collected from sampled fish by onsite fishery agency personnel. For example, the Corps requires collection of fish condition information (i.e., injury, descaling, length, weight, etc.) to detect juvenile fish passage facility problems that can descale, injure, or kill fish. The Corps also needs information regarding the numbers and weights of fish collected and the species composition for holding and loading purposes at the collector dams. This sampling effort also meets the requirements of approved monitoring programs (i.e., smolt monitoring, GBT sampling) and research (AFEP, the NWPPC's Fish and Wildlife Program), as well as new research required by this biological opinion. Given the multiple tasks accomplished under the program, the Action Agencies involved should implement cost sharing of the program. Sampled juvenile fish handling at the projects should remain the responsibility of fishery agency personnel.

10.5.1.5 Monitor Effects of Dissolved Gas Supersaturation

The Action Agencies will monitor the effects of TDG. This annual program will include physical and biological monitoring and will be developed and implemented in consultation with the Water Quality Team and the Mid-Columbia PUDs' monitoring programs.

At a minimum, the physical monitoring components of this plan will include placement of physical TDG monitors in the tailraces and forebays of all lower Snake and lower Columbia river dams and daily recording of TDG data in the Columbia River Operational Hydromet Management System (CROHMS) database. This program will also include a QA/QC component, with redundant and backup monitors at as many locations as determined necessary by the Water Quality Team; calibration of monitoring equipment at least every 2 weeks; enough funding for spot-checking monitoring equipment during the fish passage season (with the number determined in the preseason by the Water Quality Team); an error-checking, correcting, and recording function for CROHMS data; and daily data reporting. The QA/QC components will be reviewed annually and modified as improved information and techniques become available. The Action Agencies will conduct the annual review in coordination with the Water Quality Team. At a minimum, the biological monitoring components will include smolt monitoring at selected smolt monitoring locations, adult monitoring at Bonneville and Lower Granite dams, and daily data collection and reporting.

10.5.1.6 Install Adult PIT-tag Detectors to Facilitate Monitoring

BPA and the Corps will install adult PIT-tag detectors at appropriate FCRPS projects before the expected return of any adult salmon from the 2002 juvenile outmigration. If technical problems preclude installation of these detectors in this time frame, the evaluation of spring migrant transportation from McNary should be delayed until the systems are installed.

10.5.1.7 Monitor Adult Survival

The Action Agencies will conduct a comprehensive evaluation to assess survival of adult salmonids migrating upstream and factors contributing to unaccounted losses. Broad objectives for such studies may include the following:

- Evaluate survival rates between dams and through the system.
- Partition interdam losses by factor.
- Assess causal mechanisms associated with losses.
- Assess reproductive success, including causal mechanisms associated with reduced reproductive success, if any.
- Identify measures, as appropriate, to address factors affecting passage, survival, and reproductive success.

More specific investigations may include the following:

- Fallback (operational-related versus other factors)
- Passage delay (in relation to project and reservoir operations, including turbines, spill, and peaking)
- Injury (resulting from passage, marine mammals)
- Headburns
- Homing/straying
- Mainstem spawning
- Tributary turnoff and spawning
- Effect of TDG
- Effect of temperature (including use of cool water microhabitat)
- Energy expenditure
- Susceptibility to disease
- Unaccounted incidental mortality associated with harvest
- Cumulative effects (synergism)

10.5.1.8 Monitor Turbine Efficiency

BPA and the Corps will prepare an annual summary report detailing compliance with the 1% peak efficiency turbine operation guidelines for the FCRPS projects. The report should be provided to the Fish Facility Operation and Maintenance Coordination Team and NMFS by February 1 of each year.

A summary report will allow review of seasonal operation of turbine units which may reveal methods to improve operations for safe fish passage.

10.5.1.9 Report Project Operations in Timely Manner

The Corps will work through the FPOM to make hourly individual turbine unit and spill bay operation data available on its website, real time, during the juvenile migration season. These data are necessary to monitor compliance with operating criteria in the annual Fish Passage Plan (e.g., unit operating priorities and spill patterns), as well as agreed-on special project operations for research or maintenance. These data were available for some projects while information was collected for the gas-abatement program, but they have since been discontinued.

10.5.1.10 Report Progress in Implementing Fish Passage Plan in Timely Manner

The Action Agencies, in coordination with the annual planning process, will continue to provide weekly and annual reports regarding implementation of the fish passage plan to FPOM.

The current practice of providing 7-day Corps project adult/juvenile facility reports and 7-day fish transportation summarys to NMFS via electronic mail once a week has worked well and should continue. Additionally, hard copies of these reports have been formally submitted monthly. Since NMFS staff already have the desired information up to several weeks earlier, it is no longer necessary to provide formal hard copies monthly. Rather, the Corps should provide these reports to NMFS once a year (at the February FPOM meeting) in electronic format on a compact disk for archiving. Specific details should be developed in coordination with FPOM.

10.5.2 Terms and Conditions Related to Improving Juvenile and Adult Passage Survival

10.5.2.1 Develop a TDG Model to Inform Spill and TDG Management Decisions

The Action Agencies will complete development of, and continue to refine, a TDG model to be used as a river operations management tool. Once the model is developed, applications and results will be coordinated through the Water Quality Team. The Action Agencies will coordinate the systemwide management applications of gas abatement model studies with the annual planning process, the Transboundary Gas Group, the Mid-Columbia PUDs, and other interested parties.

TDG supersaturation, caused by water spilling over dams, can result in the injury or mortality of juvenile salmonids. Since the 1960s, increased hydraulic capacity at powerhouses of mainstem projects, increased water storage, and structural modification to spillways have substantially reduced this problem. High levels of TDG have, however, been measured under some river conditions even in recent years, e.g., during periods of involuntary spill.

10.5.2.2 Model Water Temperature to Inform Operational Decisions

By June 30, 2001, the Action Agencies will develop and submit for NMFS' and EPA's approval a plan to model the water temperature effects of alternative Snake River operations.

The modeling plan should focus on water temperatures in the Snake River from Hells Canyon Dam on the Snake River and from Dworshak Dam on the Clearwater River to Bonneville Dam on the Columbia River, with predictive nodes located at the near-dam forebays and tailraces of each project. Both one-dimensional and multidimensional models (due to reservoir stratification) may be needed to fully define expected temperature conditions within the reach. The models should be developed to function both as a preseason planning tool and to provide predicted outcomes of immediate operations in real time.

10.5.2.3 Develop Temperature Data Collection System to Inform Operational Decisions

The Action Agencies will develop, in consultation with EPA, NMFS, and state and Tribal water quality agencies, a temperature data collection strategy. Such a strategy is necessary for developing and operating the models and documenting the effects of project operation.

Existing water temperature and meteorological data are inadequate for this purpose. Existing data and statistical tools will be used to identify locations where additional or improved data collection, in terms of precision, accuracy, and frequency, would be most beneficial.

10.5.2.4 Assess Use of Safer PIT-tag Detection Methods

The Corps and BPA will assess less-intrusive, PIT-tag interrogation methods at FCRPS juvenile bypass systems with interrogation sites, including McNary, John Day, and Bonneville dams. The Corps and BPA shall also assess providing similar detection capability for the Ice Harbor juvenile bypass system.

The Corps and BPA should assess the use of full bypass flow PIT-tag detection, without the need to dewater and route fish through separators and sample flumes, with the possible benefit of reducing adverse survival effects of passage through multiple bypasses.

10.5.2.5 Improve Panel Design of Extended Submerged Intake Screens

The Corps will complete the extended submerged intake screen systemwide letter report and implement recommended improvements.

The Corps will complete investigation of fish performance and engineering issues pertaining to the need for improved porosity-control panel and panel connection design and install improved panels in all extended, submerged-intake screens. In particular, the Corps will develop improved vertical barrier screen (VBS) gatewell cleaning and inspection measures for McNary and John Day dams and implement them, as warranted. The Corps will also develop improved debris handling measures in the forebays and screen/bypass systems to limit juvenile injury and mortality.

10.5.2.6 Implement Studies to Reduce Bird Predation at FCRPS Projects

The Action Agencies will recover PIT-tag information from predacious bird colonies and evaluate trends, including hatchery-to-hatchery and hatchery-to-wild depredation ratios.

Evaluation of this information, when combined with bird and fish behavioral information, will help managers develop a better understanding of issues such as prey selection, stock-specific vulnerability, and potential long-term predation effects on specific listed stocks, including the effectiveness of management actions to reduce predation by birds.

10.5.2.7 Reduce Incidental Take Associated with Annual Fish Passage Plans

The Action Agencies, in coordination with the FPOM, will implement or reconcile, in writing, comments received from NMFS regarding ways of reducing incidental take in the current and future Corps' Fish Passage Plans before release of the plan each year.

Review of the final 2000 plan indicated that only about 40% of NMFS' comments (NMFS letter to William Branch, dated January 21, 2000) on the Portland District projects were addressed by the text in the plan. The Corps has to incorporate NMFS' recommendations for reducing delayed mortality or explain in writing why the recommendations were not implemented.

10.5.2.8 Reduce Mortality Associated with Special Facility Operations

All planned special facility operation activities that cause any facility to be out of compliance with the operations and criteria in the main text of the Fish Passage Plan (and expected to result in the take of listed salmon stocks) must be coordinated with NMFS through the Regional Forum process at least 1 month before the anticipated action date.

Identifying special project operations in the Fish Passage Plan does not necessarily mean that the action has undergone the requirements of ESA Section 7 consultation. Generally, this section of the plan is not ready for review with the rest of the draft plan, and insufficient consultation occurs before release of the plan. Essential information to be provided includes a brief summary of the action, location, anticipated date and time, analysis of potential impact to listed salmon stocks, and potential alternative actions.

10.5.2.9 Develop Action Plan for Reducing Steelhead Holding in John Day Fish Ladders

The Corps will use information from previous and ongoing investigations regarding the problem of adult steelhead holding and jumping in the fish ladders at John Day Dam, develop a proposed course of action, and implement as warranted.

This problem has been investigated in a fragmented manner for years. A more detailed collation of cumulative work to date is required, combined with an assessment of alternatives.

10.5.2.10 Evaluate Kelt Passage and Potential Improvements

The Corps will initiate an adult steelhead downstream migrant (kelt) assessment program to determine the magnitude of passage, their contribution to population diversity and growth, and potential actions to provide safe passage.

Evaluations should be conducted to review available literature and develop pilot testing regarding reconditioning of kelts. The Corps will assess and conduct a short-term holding evaluation at a project site where kelt are more abundant and initiate a kelt transportation pilot study as a possible means of reducing dam passage mortality. The Corps will evaluate kelt passage associated with the RSW at Lower Granite (described in Section 9.2.2.4), which will be prototype-tested in 2001 in the context of juvenile fish passage. The Corps will synthesize these work elements and report the magnitude of kelt passage to the NMFS Regional Forum, the effects of passage on their survival, and potential actions to improve their survival, if deemed appropriate, by 2003.

10.5.3 Terms and Conditions Related to FCRPS Research Projects Described in Section 9.6.5.3

The specific terms described below are addressed to “the researcher” because NMFS expects that the Action Agencies will conduct the research or contract it with other entities. These terms and conditions apply to the Action Agencies or their contractors who will conduct the research. The terms and conditions also refer to the researcher’s designated take authorization in this incidental take statement, i.e., take associated with each numbered research activity, not to an unidentified researcher. The specific terms and conditions are described below:

10.5.3.1 Special Conditions

- ESA-listed fish must be handled with extreme care and kept in water to the maximum extent possible during sampling and processing. Adequate circulation and replenishment of water in holding units is required. When using gear that captures a mix of species, ESA-listed fish must be processed first to minimize the duration of handling stress. ESA-listed fish must be transferred using a sanctuary net (which holds water during transfer) whenever necessary to prevent the added stress of being out of water. Should NMFS determine that a researcher's procedure is no longer acceptable, the researcher must immediately cease such activity until NMFS determines an acceptable substitute procedure.

- Each ESA-listed fish handled out of water must be anesthetized when necessary to prevent injury or mortality. Anesthetized fish must be allowed to recover (e.g., in a recovery tank) before being released. Fish that are simply counted must remain in water, but they do not have to be anesthetized.

- To minimize the lateral transfer of pathogens, a sterilized needle must be used for each individual injection when PIT-tagging ESA-listed fish. Sterilization methods are required for the application of surgically implanted radio transmitters.

- Whenever possible, unintentional or indirect mortalities of ESA-listed juvenile fish that occur during scientific research and monitoring activities shall be used in place of intentional lethal take, if applicable.

- Each researcher must ensure that the ESA-listed species are taken only by the means, in the areas, and for the purposes set forth in the research proposal, as limited by the terms and conditions in this incidental take statement.

- Each researcher, in effecting the take authorized by this incidental take statement, is considered to have accepted the terms and conditions of this incidental take statement and must be prepared to comply with the provisions of this incidental take statement, the applicable NMFS regulations, and the ESA.

- Each researcher is responsible for the actions of any individual operating under the authority of the researcher's designated take authorization within this incidental take statement. Such actions include capturing, handling, releasing, transporting, maintaining, and caring for any ESA-listed species authorized to be taken by this incidental take statement.

- Each researcher, staff member, or designated agent acting on the researcher's behalf must possess a copy of this incidental take statement when conducting the activities for which a take of ESA-listed species or other exception to ESA prohibitions is authorized herein.

- Researchers may not transfer or assign a take authorization included within this incidental take statement to any other person(s), as person is defined in Section 3(12) of the ESA. The take authorization ceases to be in force or effective if transferred or assigned to any other person without prior authorization from NMFS.

- Each researcher must obtain any other Federal, state, and local permits/authorizations necessary to conduct the activities provided for in this incidental take statement.

- Each researcher must coordinate with other applicable comanagers and/or researchers to ensure that no unnecessary duplication and/or adverse cumulative effects occur as a result of the researcher's activities.

- Each researcher must allow any NMFS employee(s), or any other person(s) designated by NMFS, to accompany field personnel during the activities provided for within this incidental take statement. Each researcher must allow such person(s) to inspect the researcher's records and facilities if such records and facilities pertain to ESA-listed species covered by this incidental take statement or NMFS' responsibilities under the ESA.

- Under the terms of NMFS' regulations, a violation of any of the terms and conditions of this incidental take statement will subject the offending researcher, and/or any individual who is operating under the authority of this incidental take statement, to penalties as provided for in the ESA.

- Each researcher is responsible for biological samples collected from ESA-listed species as long as they are useful for research purposes. The terms and conditions concerning any samples collected remain in effect as long as the researcher maintains authority over and responsibility for the material taken. A researcher may not transfer biological samples to anyone not listed in the research proposal without obtaining prior written approval from NMFS. Any such transfer will be subject to such conditions as NMFS deems appropriate.

- NMFS may amend a take authorization identified in this incidental take statement or adjust specific take levels after reasonable notice to the applicable researcher.

- NMFS may revoke a take authorization identified in this incidental take statement if the activities it provides for are not carried out, if the activities are not carried out in accordance with the conditions of this incidental take statement and the purposes and requirements of the ESA, or if NMFS otherwise determines that the continuation of activities would operate to the disadvantage of ESA-listed species.

10.5.3.2 Annual Reporting and Authorization Requirements

The conduct of scientific research/monitoring activities each year is contingent on submission and approval of a report on each preceding year's research and monitoring activities. Annual reports are due by January 31 of each year. The report must include the following:

- A detailed description of scientific research and monitoring activities, including the total number of fish taken at each location, an estimate of the number of ESA-listed fish taken at each location, the manner of take, and the dates and locations of the take

- Measures taken to minimize disturbances to ESA-listed fish and the effectiveness of these measures, the condition of ESA-listed fish taken and used for research and monitoring, a description of the effects of research and monitoring activities on the subject species, the disposition of ESA-listed fish in the event of mortality, and a brief narrative of the circumstances surrounding fish injuries or mortalities to ESA-listed fish

- Any problems that may arise during research and monitoring activities, and a statement as to whether the activities had any unforeseen effects

- A description of how all take estimates were derived

- Any preliminary analyses of the data

- Steps that have been and will be taken to coordinate research and monitoring activities with those of other researchers

10.5.3.3 Operational Reporting and Notification Requirements

- Researchers must provide plans for future undefined projects and/or changes in sampling locations or research/monitoring protocols and obtain NMFS' approval before implementation.

- Each researcher must alert NMFS whenever the authorized level of take is exceeded, or if circumstances indicate that such an event is imminent. Notification should be made as soon as possible, but no later than 2 days after the authorized level of take is exceeded. The researcher must then submit a detailed written report to NMFS. Pending a review of the circumstances, NMFS may suspend the research and monitoring activities or implement reasonable measures and/or alternatives to allow research and monitoring activities to continue.

- Each researcher must alert NMFS when a take of any ESA-listed species not included in the research proposal is killed, injured, or collected during the course of research and monitoring activities. Notification should be made as soon as possible, but no later than 2 days after the unauthorized take. The researcher must then submit a detailed written report to NMFS. Pending a review of the circumstances, NMFS may suspend research and monitoring activities or implement reasonable measures and/or alternatives to allow research and monitoring activities to continue.

This page is intentionally left blank.

11.0 CONSERVATION RECOMMENDATIONS

Section 11 discusses NMFS' obligation to develop conservation recommendations under Section 7 (a)(1) of the ESA, which directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and listed species. Conservation recommendations are discretionary measures suggested to minimize or avoid the potential adverse effects of a proposed action on listed species, to minimize or avoid adverse modification of critical habitat, to develop additional information, or to assist the Federal agencies in complying with the obligations under Section 7(a)(1) of the ESA. NMFS believes that the following conservation recommendations are consistent with these obligations and, therefore, supports their implementation by the Action Agencies.

11.1 CREATE SPAWNING HABITAT FOR LCR CHINOOK SALMON IN IVES ISLAND AREA BELOW BONNEVILLE DAM

As described in Section 6, the Action Agencies can augment lower Columbia River flows with upper basin reservoir storage to create spawning habitat for tule chinook salmon in the Ives Island area. Starting the flow augmentation program described in Section 9.6.1.2.1 to benefit CR chum salmon approximately 4 weeks earlier will give LCR fall chinook salmon access to this habitat. However, NMFS is concerned about whether the hydrosystem can sustain this operation during a low or average water year without an adverse effect on the ability to meet flow objectives specified in Section 9.6.1.2.1. NMFS, therefore, recommends that the Action Agencies provide flow augmentation for access to spawning habitat in the Ives Island area as early as the first week in October, if the hydroregulation studies completed by mid-September indicate that the operation will not add significant risk to operations designed to meet spawning and incubation requirements for chum salmon or spring and summer flow objectives for juvenile migrants.

11.2 EVALUATE EFFECTS OF FCRPS OPERATIONS ON INFECTIOUS DISEASE TRANSMISSION

The Corps should evaluate the cumulative effects of delay and temperature on the transmission occurrence and level of infectious diseases. Adult passage delay has been documented at FCRPS hydro projects, but effects of cumulative delay passing the FCRPS hydrosystem (including increased exposure to elevated temperatures) have not been adequately addressed.

11.3 DEVELOP ANESTHETIC THAT WILL MEET FDA REQUIREMENTS

The Corps should identify and develop an anesthetic appropriate for use on salmonids in mainstem trapping facilities and other locations, and should seek Food and Drug Administration (FDA) and any other necessary approvals for its use. The anesthetic must meet a number of criteria, including ease of use (when large numbers of fish must be handled) and low immediate and delayed handling mortality. In addition, any fish released back into the river must be safe for consumption by fishers who may catch those fish after they are trapped.

Trapping and sampling components of each run of adult salmonids at mainstem locations is a fundamental requirement for monitoring ESU status, run performance, and effectiveness of hydrosystem operations. Trapping facilities are also important for reducing the straying of hatchery fish into natural production areas. Handling large numbers of fish during trapping operations requires using an anesthetic to calm the fish, thereby reducing injuries and mortalities. Anesthetics currently used in the Columbia River basin include MS-222 (tricaine methanesulfonate or ethyl m-aminobenzoate sulphonate), clove oil, and carbon dioxide. Each substance is considered effective for anesthetic use, but each also has drawbacks. For example, carbon dioxide can result in increased injuries due to thrashing of the fish during recovery, particularly as water temperatures increase. MS-222 has not been approved for use in fish that may be consumed within 21 days of use. Therefore, it is critical to evaluate all potential anesthetics and to identify and adopt the most effective substance, based on minimizing injuries and lasting effects on salmonid survival and eliminating health risks to consumers. The anesthetic finally adopted may already be one in use, but with possible modifications to existing methods. It is also possible that different substances may be found effective for different objectives or under different conditions.

11.4 EVALUATE EFFECTS OF SHAD

The Corps should evaluate the effects of large numbers of shad in fish ladders on adult salmon migratory behavior, timing, and passage. Delay and accumulations of shad in fish ladders may contribute to delay of adult salmonids migrating through the FCRPS hydrosystem.

The Corps and BPA should also evaluate the effects large numbers of juvenile shad may have on the food base for juvenile salmon.

For NMFS to be kept informed of actions to minimize or avoid adverse effects or to benefit listed species or their habitats, NMFS requests notification of the implementation of any conservation recommendation.

11.5 EVALUATE MOVING LOWER COLUMBIA RIVER FLOW MEASUREMENT LOCATION

The Action Agencies, in coordination with NMFS, will evaluate the hydrologic effects of moving the lower Columbia River flow measurement location from McNary Dam to Bonneville or The Dalles Dams. To do so, the parties will develop new flow objectives for those sites.

The present flow objectives were developed using available fish survival data at various locations in the basin. McNary Dam was selected as a flow measurement location because 1) data were available to define a flow objective, 2) it is located downstream of the confluence of the Snake and Columbia rivers, and 3) little active storage is provided by downstream FCRPS projects. Changing the flow objective to The Dalles or Bonneville Dam would include the streamflow depletion effects of BOR's projects located downstream of McNary Dam, as well as other water diversions from the lower Columbia River.

11.6 IMPROVE RUNOFF VOLUME FORECASTING

The Action Agencies will provide funding for improved runoff forecasts in storage reservoir basins. To improve forecasts may involve supporting such measures as improved forecasting methodologies, low elevation snowpack estimation by plane, addition of snow telemetry sites, improved maintenance and reliability of snow telemetry sites, and additional snow monitoring sites.

Accurate runoff forecasts are extremely important in managing Columbia Basin runoff for multipurpose uses such as electrical energy, flood control, and listed and unlisted fish species. Forecasting errors can cause too much water to be drafted for flood control, resulting in shortfalls of water for listed species and reservoir refill failures. The Libby basin is a site where runoff forecasting has to be improved. Water in that basin is needed to protect and enhance three listed species: salmon, bulltrout, and sturgeon. The average April-through-August runoff volume from 1960 to 1989 has been 6.4 Maf; the average forecast error has been 1.5 Maf, or 23.4%. In 2000, forecasts indicated that water would be available for sturgeon, bulltrout, and salmon. Libby Reservoir did not fill enough to provide any salmon augmentation water, however.

11.7 EXPLORE CHANGES IN KOOTENAY LAKE OPERATING RANGE WITH CANADIAN ENTITIES

The Corps, in coordination with USFWS and NMFS, will explore the opportunity to change Kootenay Lake regulation to increase its benefit to listed salmon and sturgeon. Increasing the operating range of Kootenay Lake, particularly the upper limit, would allow additional spring water storage and summer delivery that, by augmenting summer flows, would benefit listed salmon downstream. USFWS has also requested such changes in Kootenay Lake operations to improve sturgeon spawning in the Kootenai River downstream of Libby Dam.

11.8 PARTICIPATE IN DEVELOPING MAINSTEM TMDLS

The Action Agencies will participate in developing the Columbia-Snake River mainstem TMDLs for TDG and water temperature. The Action Agencies will also participate in the collaborative process of developing the implementation plan resulting from the TMDLs.

The Columbia-Snake River mainstem TMDLs are being developed by EPA and the states of Oregon, Washington, and Idaho under court order. The TMDLs will establish load allocations for TDG and temperature for the mainstem Snake River from RM 188 to its confluence with the Columbia River and for the mainstem Columbia River from the Canadian Border to the Astoria Bridge. The water quality plan (Appendix B) presents a conceptual strategy for the TMDL implementation plan. The plan should enable future decisions on study results from RPAs identified in the biological opinion (Appendix B, Table B-2) and should also help determine future decisions on studies identified as conservation measures (Appendix B, Table B-3).

The TMDL provides a useful tool under the CWA for developing a strategy to move toward attaining water quality standards. Participation by the Action Agencies with the states, EPA, the Tribes, and other Federal agencies and private entities in monitoring, modeling, data analysis, and action-item selection will yield a more coordinated and collaborative plan for moving toward standard attainment. Coordination with tributary TMDL and water quality standard attainment efforts will also benefit mainstem water quality efforts (conservation recommendation 11.11).

11.9 CONDUCT LONG-TERM GAS-ABATEMENT ALTERNATIVE STUDY

The Action Agencies should continue to conduct a long-term gas-abatement alternative selection study for the following FCRPS projects: Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, Bonneville, and Grand Coulee dams. The study would be a follow-up evaluation of long-term structural gas-abatement alternatives based on the results of 1) the Corps' systemwide gas-abatement study due to be completed in spring 2001 and 2) the BOR's recently completed feasibility study of gas abatement alternatives at Grand Coulee Dam.

11.10 SUPPORT FEDERAL HABITAT TEAM

To ensure that Federal support for non-Federal habitat initiatives is effective, clear, regular, and predictable across Federal and non-Federal lands, lines of coordination will be needed among Federal agencies and between Federal and non-Federal entities. In the basinwide strategy, the Federal agencies propose to ensure coordination through a Federal Habitat Team.

The Action Agencies should enter into a memorandum of understanding with other Federal habitat agencies establishing a Federal Habitat Team to coordinate Federal activities across Federal and non-Federal lands. During the team's first year, BPA will provide a coordinator and administrative support. Thereafter, the Action Agencies should develop an agreement with other agencies participating on the team to share funding, staff, and administrative support.

11.11 PROVIDE FUNDING TO DEVELOP TMDLS

BPA should strongly consider providing funds to states, Tribes, and/or approved local planning entities that are prepared to develop TMDLs at the watershed level as part of implementing a completed subbasin plan.

Section 9.6.2 of this document and Section 3 of the basinwide strategy cite the importance of water quality to ensuring properly functioning conditions within tributary spawning and rearing habitat. They also name water quality compliance as a key objective in meeting the biological needs of listed salmonids. While water quality compliance is a delegated state responsibility under the CWA, these processes complement, and in some cases can facilitate, accomplishing ESA goals.

In cases where states, Tribes, and/or local planning entities are prepared to embrace TMDLs as mechanisms for achieving recovery of listed species, and in particular when no other funding sources are available, BPA should consider providing funds to assist in their development. Planning and developing TMDLs are necessary prerequisites to implementing legally sanctioned water quality improvements likely to result in biological benefits for listed species. NMFS can foresee situations in which TMDLs may be the appropriate remedies for addressing the biological needs of salmon and steelhead, but in which resources are insufficient to support participation by the affected parties. In those cases, BPA can play a beneficial role on behalf of the resource.

11.12 PROVIDE ALTERNATIVE FISHING LOCATIONS

Working through regional priority processes and in collaboration with state, Tribal, and Federal fishery managers, the Action Agencies will contribute to the identification, development, and establishment of alternative terminal fishing opportunities.

Fishery opportunities can be recreated, expanded, and/or improved in known-stock terminal areas where abundant fish can be harvested with minimal impacts on listed fish, provided the brood stock is appropriate to the area and/or unwanted straying is minimal. Those areas could potentially reduce fishing pressures in existing mixed stock areas, particularly for Tribal fisheries that are already oriented toward terminal fishing. This strategy will be effective for Tribal fisheries only to the extent that the affected Tribes are fully engaged in the planning process to ensure that usual and accustomed fishing areas, catch distribution, and other considerations receive appropriate respect.

11.13 PROVIDE FISHERY EFFORT REDUCTION PROGRAMS

Working through regional prioritization processes and in collaboration with state, Tribal, and Federal fishery managers, the Action Agencies will help develop and implement effective fishery effort reduction programs. The programs will be designed to add value to the catch in commercial fisheries in the basin by such means as price supports, value-added processing, and other strategies for mitigating the effects of harvest constraints necessitated by the status of natural populations.

Programs and strategies may include, but are not limited to, voluntarily buying out and retiring commercial fishing licenses and permits (particularly when catch reductions in harvest of listed species are needed), purchasing harvest conservation easements to further reduce impacts on listed fish in commercial fisheries, and identifying economic development strategies designed to enhance fishery values, even in the face of smaller catches. Innovative strategies might include the price supports and value-added measures mentioned above, or other strategies that enhance fishery values.

12.0 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

Public Law 104-267, the Sustainable Fisheries Act of 1996, amended the Magnuson-Stevens Act to establish new requirements for essential fish habitat (EFH) descriptions in Federal fishery management plans and to require Federal agencies to consult with NMFS on activities that may adversely affect EFH. EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (Magnuson-Stevens Act, Section 3)." The Secretary of Commerce has designated EFH for the Federally managed groundfish, coastal pelagics, and Pacific salmon fisheries (PFMC 1998a,b, PFMC 1999) as those waters and substrate necessary to ensure the production needed to support a long-term sustainable fishery. That is, EFH provides the properly functioning habitat conditions necessary for the long-term survival of the species over the full range of environmental variation.

The Magnuson-Stevens Act consultation requirements apply to all actions that may adversely affect EFH, regardless of their location. Any reasonable attempt to encourage the conservation of EFH must take into account actions that occur outside EFH, such as upstream and upslope activities that may have an adverse effect on EFH.

The consultation requirements of Section 305(b) of the Magnuson-Stevens Act [16 USC 1855(b)] provide that:

- Federal agencies must consult with NMFS on all actions, or proposed actions, authorized, funded, or undertaken by the agency, that may adversely affect EFH.

- NMFS shall provide conservation recommendations for any Federal or state activity that may adversely affect EFH.

- Federal agencies shall, within 30 days after receiving conservation recommendations from NMFS, provide NMFS with a detailed response in writing regarding the conservation recommendations. The response shall include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the conservation recommendations of NMFS, the Federal agency shall explain its reasons for not following the recommendations.

12.1 ESSENTIAL FISH HABITAT IN THE COLUMBIA RIVER BASIN

The Columbia River estuary and the Pacific Ocean off the mouth of the Columbia River are designated EFH for groundfish and coastal pelagic species (see Table 12.1-1, PFMC 1998a,b). The marine extent of groundfish and coastal pelagic EFH includes waters from the nearshore and tidal submerged environments within Washington, Oregon, and California state territorial waters out to the exclusive economic zone (370.4 km) offshore between the Canadian border to the north and the Mexican border to the south.

PFMC has recommended to the Secretary of Commerce an EFH designation for the Pacific salmon fishery that includes all streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon in Washington, Oregon, Idaho, and California, except above the impassable barriers identified by PFMC (1999). Chief Joseph Dam, Dworshak Dam, and the Hells Canyon Complex (Hells Canyon, Oxbow, and Browne dams) are among the listed manmade barriers that represent the upstream extent of the Pacific salmon fishery EFH. Salmon EFH excludes areas upstream of longstanding, naturally impassable barriers (e.g., natural waterfalls in existence for several hundred years). In the estuarine and marine areas, the designated salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (370.4 km) offshore of Washington, Oregon, and California north of Point Conception (PFMC 1999).

Table 12.1-1. Species with designated EFH found in waters of proposed FCRPS action area.

Groundfish Species	Blue rockfish (S. mystinus)	Rougheye rockfish (S. aleutianus)	Flathead sole (Hippoglossoides elassodon)
Leopard shark (Triakis semifasciata)	Bocaccio (S. paucispinis)	Sharpchin rockfish (S. zacentrus)	Pacific sanddab (Citharichthys sordidus)
Soupfin shark (Galeorhinus zyopterus)	Brown rockfish (S. auriculatus)	Shortbelly rockfish (S. jordani)	Petrale sole (Eopsetta jordani)
Spiny dogfish (Squalus acanthias)	Canary rockfish (S. pinniger)	Shortraker rockfish (S. borealis)	Rex sole (Glyptocephalus zachirus)
Big skate (Raja binoculata)	Chilipepper (S. goodei)	Silvergray rockfish (S. brevispinus)	Rock sole (Lepidopsetta bilineata)
California skate (R. inornata)	China rockfish (S. nebulosus)	Speckled rockfish (S. ovalis)	Sand sole (Psettichthys melanostictus)
Longnose skate (R. rhina)	Copper rockfish (S. caurinus)	Splitnose rockfish (S. diploproa)	Starry flounder (Platyichthys stellatus)
Ratfish (Hydrolagus colliei)	Darkblotched rockfish (S. crameri)	Stripetail rockfish (S. saxicola)	
Pacific rattail (Coryphaenoides acrolepsis)	Grass rockfish (S. rastrelliger)	Tiger rockfish (S. nigrocinctus)	**Coastal Pelagic Species**
Lingcod (Ophiodon elongatus)	Greenspotted rockfish (S. chlorostictus)	Vermillion rockfish (S. miniatus)	Northern anchovy (Engraulis mordax)
Cabezon (Scorpaenichthys marmoratus)	Greenstriped rockfish (S. elongatus)	Widow Rockfish (S. entomelas)	Pacific sardine (Sardinops sagax)
Kelp greenling (Hexagrammos decagrammus)	Longspine thornyhead (Sebastolobus altivelis)	Yelloweye rockfish (S. ruberrimus)	Pacific mackerel (Scomber japonicus)
Pacific cod (Gadus macrocephalus)	Shortspine thornyhead (Sebastolobus alascanus)	Yellowmouth rockfish (S. reedi)	Jack mackerel (Trachurus symmetricus)
Pacific whiting (Hake) (Merluccius productus)	Pacific Ocean perch (S. alutus)	Yellowtail rockfish (S. flavidus)	Market squid (Loligo opalescens)
Sablefish (Anoplopoma fimbria)	Quillback rockfish (S. maliger)	Arrowtooth flounder (Atheresthes stomias)	
Aurora rockfish (Sebastes aurora)	Redbanded rockfish (S. babcocki)	Butter sole (Isopsetta isolepsis)	**Salmon**
Bank Rockfish (S. rufus)	Redstripe rockfish (S. proriger)	Curlfin sole (Pleuronichthys decurrens)	Coho salmon (O. kisutch)
Black rockfish (S. melanops)	Rosethorn rockfish (S . helvomaculatus)	Dover sole (Microstomus pacificus)	Chinook salmon (O. tshawytscha)
Blackgill rockfish (S. melanostomus)	Rosy rockfish (S. rosaceus)	English sole (Parophrys vetulus)	

Sources: Casillas et al. 1998, Eschmeyer et al. 1983, Miller and Lea 1972, Monaco et al. 1990, Emmett et al. 1991, Turner and Sexsmith 1967, Roedel 1953, Phillips 1957, Roedel 1948, Phillips 1964, Fields 1965, Walford 1931, Gotshall 1977, Hart 1973, Healey 1991, Sandercock 1991, and Dees 1961.

12.2 SUMMARY OF PROPOSED ACTION

Below is a brief description of the proposed action. For a more detailed description, see Section 3.

12.2.1 Operation and Configuration of FCRPS

The FCRPS serves an array of individual project and system purposes. Individual purposes vary widely and may include power generation, flood control, irrigation, recreation, and fish and wildlife benefits. Congress authorized all 30 of BOR's projects in the basin to provide water for irrigated agriculture; all the projects except Hungry Horse Dam and Reservoir currently fulfill the congressional mandate.

12.2.2 Flow Objectives for Salmon and Steelhead

The Action Agencies recommend that mainstem flow operations be based on the 1995 RPA as supplemented by the 1998 FCRPS Biological Opinion. System operators will continue to confer with NMFS and the regional fisheries comanagers to determine how to best manage in-season conditions relative to the seasonal average flow objectives.

For fall chinook and chum salmon spawning below Bonneville Dam, the FCRPS would be operated to use storage to augment natural flows, attempting to provide a flow level of 125 kcfs during early November through early April while maintaining the 1995 RPA requirement for storage projects to be at their upper (flood control) rule curve elevation on April 10 of each year. As natural conditions permit, a conservative stepwise approach would allow higher flows during late fall and early winter.

12.2.2.1 Water Quality

The Action Agencies propose to continue to operate the FCRPS to reduce water temperatures during periods of juvenile and adult fish migration and to minimize the harmful effects of elevated levels of spill-generated TDG on anadromous and resident fish.

12.2.2.2 Specific Project Operations

See Section 3 for a detailed discussion of specific project operations.

12.2.2.3 Spill for Fish Passage

Spill reduces turbine-related mortality of juvenile salmon and steelhead at lower Snake and Columbia River hydroelectric projects. It will be maintained at the levels recommended in the 1998 FCRPS Supplemental Biological Opinion, assuming that variances to exceed 110% TDG state water quality standards are obtained from Oregon and Washington.

12.2.2.4 Juvenile Fish Transportation

Juvenile salmonids would be collected at several dams on the lower Snake and Columbia rivers and transported downstream by truck or barge to release points below Bonneville Dam in an effort to improve survival over that experienced by inriver migrants.

12.2.2.5 Minimum Operating Pool (MOP)

Some mainstem run-of-river FCRPS reservoirs on the lower Snake River and John Day Reservoir on the Columbia River would be lowered during the spring and summer migration periods to increase water velocity (intended to increase the migration rate and survival of salmon).

12.2.2.6 Peak Turbine Efficiency Operation

The Action Agencies would operate turbines at the eight FCRPS mainstem Snake and Columbia river projects at high efficiency (within 1% of peak operating efficiency) to reduce the mortality of fish passing through the turbines.

12.2.2.7 Fish Passage Facilities

Turbine intakes with bypass/collection facilities at Lower Granite, Little Goose, Ice Harbor, Lower Monumental, McNary, John Day, and Bonneville dams would be screened. An ice and trash sluiceway passage would be provided at The Dalles Dam. Water would be spilled through the spillway to enhance fish passage.

12.2.2.8 Predator Control Program

The Northern Pikeminnow Management Program would continue. Efforts to relocate Caspian terns from Rice Island would continue.

12.2.2.9 Adaptive Management Framework Through Adoption of Performance Measures

Use of adaptive management would avoid jeopardy and facilitate the future recovery of listed stocks. Applying the “Construct for Achieving Survival Improvements” (BPA et al. 1999) would establish measurable biological performance standards for the hydrosystem, prioritize actions, and estimate the likely outcome of future actions. Ongoing studies would aid in evaluating the feasibility of lower Snake River actions, such as dam breaching, and the John Day phase 1 report (Corps 2000b) that addresses juvenile fish passage alternatives. Measures would be undertaken to improve TDG and temperature conditions for the benefit of anadromous and resident species. Changes in storage project operations and configurations in the Snake and lower Columbia rivers would benefit anadromous species. The Action Agencies' Construct would establish an overall recovery goal.

The Action Agencies recommend that interim performance standards be developed during consultation to enhance decision-making and to provide a model for developing performance standards for the Basinwide Recovery Strategy.

12.2.2.10 NMFS' Issuance of Section 10 Permit for JFT

NMFS extended the Corps' existing Permit 895 under authority of Section 10 of the ESA and the NMFS regulations governing ESA-listed fish and wildlife permits (50 CFR Parts 217 through 227). The permit is valid until December 31, 2000. The Corps has conducted a feasibility study (Corps 1999c) to evaluate several alternatives to juvenile fish transportation. Permit 895 also authorizes the Corps' annual incidental takes of ESA-listed adult fish associated with fallbacks through the juvenile fish bypass systems at the four dams.

12.3 EFFECTS OF PROPOSED ACTION

12.3.1 General Considerations

As described above in Section 5.3, the activities proposed for the configuration and operation of the FCRPS are likely to continue to reduce the function of already impaired EFH and retard the long-term progress of the impaired habitat toward properly functioning conditions. Direct effects of the FCRPS on EFH include blockage of habitat and habitat alteration.

By providing a storage capacity for almost 40% of the average annual runoff of the Columbia River above Bonneville Dam and operating to meet electrical generation, flood control, and irrigation demands, reservoir operations have changed streamflow conditions affecting turbidity and sediment transport, estuary conditions, and the extent and characteristics of the Columbia River plume. Reservoir operations on the mainstem Columbia and Snake rivers have altered the natural runoff pattern in the basin by increasing fall and winter flows, decreasing spring and summer flows, and effectively increasing the cross-sectional area of the river, resulting in downstream migration delays. Reduced flows result in substantial modification of the rivers' thermal regime and water quality by increasing water temperatures and altering water chemistry.

The effects of water regulation and impoundments effectively transform an ecosystem dependent on moving water (lotic habitat) into one dependent on still water (lentic habitat). This results in substantial changes in the distribution, abundance, and diversity of organisms and in the carrying capacity of the habitat, as well as changed predator-prey dynamics. Because reservoirs have low water velocity, changes in water temperature, dissolved oxygen levels, turbidity, water chemistry, and aquatic habitat may result. Thermal and chemical stratification are likely to occur, with potentially significant effects on associated aquatic life in and downstream of the reservoir. Specific downstream effects are likely to depend on site, water quality, size of impoundment, and facility design.

12.3.2 Estuary and Nearshore Essential Fish Habitat

12.3.2.1 Groundfish EFH

Flow changes in the estuary as a result of changes in the FCRPS have the potential to adversely affect estuarine EFH for groundfish and coastal pelagic species, primarily by altering the distribution of salt water and freshwater. Increased river flow will decrease both the extent and the duration of intrusion by salt water into the estuary, while decreased river flows will do the opposite. Changes in flow can also affect the nearshore ocean environment by altering the size of the freshwater plume, which will alter the availability of habitat in the immediate area offshore of the mouth of the Columbia River. Predicting the precise impact on EFH is not possible until the relationship between the physical parameters of the plume and the biology of fish is better understood.

The estuary is used by juveniles of several groundfish species as a rearing area. The dominant species in the Columbia River are starry flounder and English sole. They occur in the estuary primarily as different-age juveniles that use the channel as a migratory corridor to rearing areas in the bays and intertidal areas. These areas have large concentrations of food organisms such as the amphipod *Corophium salmonis* and are important rearing habitat. The less-than-1-year-old juveniles occur throughout the estuary, but are more concentrated in the freshwater and low-salinity areas. They are generally not as abundant in the estuary as the older age classes. One- to 2-year-old juveniles occur throughout the estuary, but are abundant year-round in the side channels and bays and also in the main navigation channel. Two-year-old juveniles are less widespread and occur mostly in the higher-salinity parts of the lower estuary.

Altering the flow patterns has the potential to affect the value of these habitats for rearing juvenile flounders if the change occurs in the summer when they are in the estuary. The dominant flatfish species is the starry flounder, which is euryhaline and extremely tolerant of wide ranges of salinity. Starry flounder, for example, have been captured as far upstream as Portland in totally freshwater systems. Consequently, unless the change from altering flow patterns is extremely large, it is unlikely that it will have an effect beyond that to which this species can adjust. Altering salinity patterns may also affect prey items for groundfish species, which could conceivably affect rearing success. These species are generalist feeders and would probably find other prey items if one group was negatively affected by a change in flow patterns.

12.3.2.2 Coastal Pelagics EFH

Only the northern anchovy of the coastal pelagic group uses the Columbia River estuary to any extent. Individuals that occur in the estuary are an extension of the coastal population and occur primarily in the lower estuary, where salinity is high. Though anchovies spawn in the ocean, all life stages can occur in the estuary. Eggs and larvae can apparently be swept into the estuary by flood tides. Individuals less than 1 year old, however, are not abundant in the estuary, whereas anchovies 1 year or older actively move into the estuary and can be abundant, particularly during periods of low river flow, when salinity is high. Anchovies are pelagic feeders, feeding primarily on copepods.

Changes in flow regulation are not expected to adversely affect anchovy EFH in the Columbia River, because all areas except the lower estuary are used irregularly. High river flows may reduce the extent of this upstream, marginally important, habitat for anchovies.

12.3.2.3 Salmon EFH

Flow changes in the estuary as a result of changes in the FCRPS have the potential to adversely affect estuarine EFH for chinook and coho salmon, primarily by altering the distribution of salt water and freshwater. Increased river flow will decrease both the extent and the duration of intrusion by salt water into the estuary, while decreased river flows will do the opposite. Changes in flow can also affect the nearshore ocean environment by altering the size of the freshwater plume, which will change the availability of habitat in the immediate area offshore of the mouth of the Columbia River. Predicting the precise impact on EFH is not possible until the relationship between the physical parameters of the plume and the biology of salmon is better understood.

Water developments in the Columbia River have reduced average flow, altered the seasonality of Columbia River flows and sediment discharge, and changed the estuarine ecosystem (NRC 1996; Sherwood et al. 1990; Simenstad et al. 1990, 1992; Weitkamp 1994). Annual spring freshet flows (May and June) through the Columbia River estuary are about 70% of predevelopment levels, and total sediment discharge is about one-third of 19th-century levels.

Decreased spring flows and sediment discharges have also reduced the extent, speed of movement, thickness, and turbidity of the plume that extended far out and south into the Pacific Ocean during the spring and summer (Barnes et al. 1972, Cudaback and Jay 1996; Hickey et al. 1998). Pearcy (1992) suggested that low river discharge is unfavorable for juvenile salmonid survival, despite some availability of nutrients from upwelling, because of reduced turbidity in the plume (increasing foraging efficiency of birds and fish predators, increased residence time of the fish in the estuary and near the coast where predation is high, decreased incidence of fronts with concentrated food resources for juvenile salmonids, and reduced overall total secondary productivity based on upwelled and fluvial nutrients). Reduced secondary productivity not only affects salmonid food sources, but also focuses predation by other fishes and birds on the juvenile salmonids.

Because of decreased river flows and development of the hydrosystem, juvenile migrant salmon probably arrive in the estuary later than under conditions in which they evolved. Efforts to make conditions in the Columbia River plume similar to those that existed before development of the hydrosystem would likely benefit salmonids (NRC 1996). Although the effects of reduced or altered flow timing from individual tributaries (e.g., the Snake River) in the estuary and nearshore ocean are minimal, collectively they are not.

Small changes in salinity distribution may have significant effects on the ecology of fishes, including salmonids. Salinity distribution, as affected by tidal flow and river discharge, is a primary factor explaining seasonal species distributions and the structure of entire assemblages of fish and epibenthic and benthic invertebrate prey species throughout the Columbia River estuary (Haertel et al. 1969; Bottom and Jones 1990; Jones et al. 1990). By altering the distribution of preferred habitats within particular salinity ranges and the particular suite of species that salmon encounter at different locations during their estuarine residence, small changes in salinity structure may have consequences for estuarine food webs and fish production in the estuary. In particular, small changes in the distribution and gradient of oligohaline salinities could change the type of habitats available when juvenile salmon must make the critical physiological transition from riverine to brackish salinities. Assessments of the ecological effects of salinity change on estuarine fishes, rearing conditions at specific places, and times that support at-risk populations are needed to assess the impacts of altered flow regimes in the estuary.

12.3.2.4 Mainstem Essential Fish Habitat

Mainstem EFH provides the migratory corridor for juvenile salmonids and returning adults. In the Columbia River basin, dams built to provide hydropower and reservoirs built for water storage and flood control may adversely affect salmon EFH. Potential adverse effects include impaired fish passage (including blockages and diversions); altered water temperature, water quality, water quantity, and flow patterns; interrupted transport of the nutrients, large woody debris, and sediment that affect river, wetland, riparian, and estuarine systems; increased competition with non-native species; and increased predation and disease.

Hydrologic effects of dams include water-level fluctuations, altered seasonal and daily flow regimes, reduced water velocities, and reduced discharge volume. These altered flow regimes can affect the migratory behavior of juvenile salmonids. Water-level fluctuations associated with hydropower peak operations may reduce habitat availability, inhibit the establishment of aquatic macrophytes that provide cover for fish, and sometimes strand fish or allow desiccation of spawning redds. Drawdowns reduce available habitat area and concentrate organisms, potentially increasing predation and transmission of disease (Spence et al. 1996). Drawdown in the fall for flood control produces high flows during spawning. The high flows allow fish to spawn in areas that may not have water during the winter and spring, resulting in loss of the redds.

12.4 CONCLUSION

NMFS believes that the proposed action may adversely affect designated EFH for groundfish and coastal pelagics listed in Table 12.1-1 and designated EFH for chinook and coho salmon.

12.5 EFH CONSERVATION RECOMMENDATIONS

Conservation measures are discretionary measures suggested to avoid, minimize, or otherwise offset adverse modification of EFH, or to develop additional information. The RPA detailed in Section 9, along with the reasonable and prudent measures and the terms and conditions that implement them (listed in Sections 10.4 and 10.5), are applicable to designated groundfish and coastal pelagics EFH and designated Pacific salmon EFH.

Because listed fish in the Columbia River are in such precarious condition, the habitat strategy is intended to accelerate efforts to help fish in priority areas in the short term, while laying a foundation for long-term strategies through subbasin and watershed assessment and planning.

In the short term, in the Basinwide Recovery Strategy, Federal agencies commit to focus immediate attention on priority subbasins, i.e., those with potential for significant improvement in anadromous fish productive capacity as a result of habitat restoration. The Basinwide Recovery Strategy identifies short-term actions, timelines, and responsible Federal agencies. This biological opinion identifies the Action Agencies' contribution to the Basinwide Recovery Strategy.

Over the long term, the habitat strategy has three overarching objectives: 1) protect existing high-quality habitat, 2) restore degraded habitats on a priority basis and connect them to other functioning habitats, and 3) prevent further degradation of tributary and estuarine habitats and water quality. Estuarine protection and restoration must play a vital role in rebuilding the productivity of listed salmon and steelhead throughout the Columbia River basin. The states of Oregon and Washington, with congressional authorization under the CWA, have developed a Comprehensive Conservation and Management Plan through LCREP. The Federal agencies strongly support the actions of this plan that contribute to salmon recovery and seek to expand on them.

The following action items call on the Action Agencies, primarily the Corps and BPA, to play an important role in estuary restoration efforts. The Corps is meant to play a lead role, with BPA primarily providing cost-share funding. Corps and BPA actions are not meant to hinge on LCREP approval, but they are meant to be fully coordinated with LCREP.

Action 158: During 2001, the Corps and BPA shall seek funding and develop an action plan to rapidly inventory estuarine habitat, model physical and biological features of the historical lower river and estuary, identify limiting biological and physical factors in the estuary, identify impacts of the FCRPS on habitat and listed salmon in the estuary relative to other factors, and develop criteria for estuarine habitat restoration.

A good deal is unknown about the ecology of the Columbia River estuary insofar as it affects listed species. It is important to develop a better understanding of historical salmon rearing patterns in the estuary; historical changes in the distribution, amounts, and classes of estuarine and floodplain habitat available to juvenile salmonids; variability in salinity, temperature, water depth, velocity, dissolved oxygen, and turbidity; habitat-salmon associations; sedimentation rates; salmon and habitat conditions in the transition zone; long-term variability and trends in the size, timing, and abundance of hatchery and wild out-migrants from the Columbia River; and the relative effects of inflow from upriver, changes in bathymetry due to the navigation channel, and changes in habitat due to other forms of development. Under this action item, the Corps and BPA are expected to develop programs to build an understanding of these matters and, in the relatively short term, to develop criteria for estuarine habitat restoration on the basis of the best available information.

***Action 159*:** BPA and the Corps, working with LCREP and NMFS, shall develop a plan addressing the habitat needs of salmon and steelhead in the estuary.

BPA and the Corps, working with LCREP and NMFS, will develop specific plans for salmon and steelhead habitat protection and enhancement. These plans should contain clear goals for listed salmon conservation in the estuary, identify habitats with the characteristics and diversity to support salmon productivity, identify potential performance measures, identify flow requirements to support estuarine habitat requirements for salmon, and develop a program of research, monitoring, and evaluation. The plans should be completed by 2003.

Action 160: The Corps and BPA, working with LCREP, shall develop and implement an estuary restoration program with a goal of protecting and enhancing 10,000 acres of tidal wetlands and other key habitats over 10 years, beginning in 2001, to rebuild productivity for listed populations in the lower 46 river miles of the Columbia River. The Corps shall seek funds for the Federal share of the program, and BPA shall provide funding for the non-Federal share. The Action Agencies shall provide planning and engineering expertise to implement the non-Federal share of on-the-ground habitat improvement efforts identified in LCREP, Action 2.

Much of the complexity of the estuary's historical shallow-water habitat and much of the estuary's saltwater wetlands have been lost due to the effects of local, navigational, and hydropower development. LCREP proposes a 10-year program to protect and enhance high-quality habitat on both sides of the river to support salmon rebuilding. A high priority should be put on tidal wetlands and other key habitats to rebuild productivity in the lower 46 river miles. Federal agencies will provide technical and financial support for this program, and for implementing on-the-ground activities identified in planning.

As more information is gained from inventory and analytical work, the 10,000-acre goal may be modified to ensure that habitats that are determined to be important to the survival and recovery of anadromous fish are addressed. Examples of acceptable estuarine habitat improvement work include the following:

- Acquiring rights to diked lands
- Breaching levees
- Improving wetlands and aquatic plant communities
- Enhancing moist soil and wooded wetland by better management of river flows
- Reestablishing flow patterns that have been altered by causeways
- Supplementing the nutrient base by importing nutrient-rich sediments and large woody debris into the estuary
- Modifying the abundance and distribution of predators by altering their habitat
- Creating wetland habitats in sand flats between the north and south channels
- Creating shallow channels in intertidal areas
- Enhancing connections between lakes, sloughs, side channels, and the main channel

The Corps and BPA will put high priority on improving access to and the quality of chum habitat, especially in the Grays River. The work outlined in this action is in addition to any mitigation/restoration work that may be connected to the Corps' channel deepening project.

***Action 161*:** Between 2001 and 2010, the Corps and BPA shall fund a monitoring and research program acceptable to NMFS and closely coordinated with the Conservation Reserve Enhancement Program monitoring and research efforts (Management Plan Action 28) to address the estuary objectives of this biological opinion.

***Action 162*:** During 2000, BPA, working with NMFS, shall continue to develop a conceptual model of the relationship between estuarine conditions and salmon population structure and resilience. The model will highlight the relationship among hydropower, water management, estuarine conditions, and fish response. The work will enable the agencies to identify information gaps that have to be addressed to develop recommendations for FCRPS management and operations.

Action 163: The Action Agencies and NMFS, in conjunction with the Habitat Coordination Team, will develop a compliance monitoring program for inclusion in the first 1- and 5-year plans.

Compliance monitoring is necessary to determine how well management actions are implemented. From a regulatory perspective, compliance monitoring is necessary to ensure that agencies and individuals responsible for mitigation or restoration activities complete their responsibilities. From a biological perspective, NMFS must know how well a management action is implemented. If salmon do not respond, NMFS will be able to distinguish between management that did not work and management that was not implemented.

Some compliance monitoring will be conducted during the monitoring and evaluation program outlined in Section 9.6.5. However, not all sites will be checked at the appropriate intervals during this program. Therefore, the agency or party conducting each action will be responsible for keeping a log book of implementation, which is entered monthly into a web-based data archive. NMFS will randomly send out field staff to check on the log books and validate their entries.

12.6 STATUTORY REQUIREMENTS

The Magnuson-Stevens Act and Federal regulations (50 CFR Section 600.920) to implement the EFH provisions require Federal Action Agencies to provide a written response to EFH conservation recommendations within 30 days of receipt. Because the EFH designation for the Pacific salmon fishery has yet to be approved, this regulation does not apply for the salmon species involved in this consultation until the Secretary of Commerce approves it, at which time the 30-day period will begin. The final response must include a detailed description of measures proposed to avoid, mitigate, or offset the adverse impacts of the activity. If the response is inconsistent with the EFH conservation recommendations, an explanation of the reasons for not implementing them must be included.

12.7 CONSULTATION RENEWAL

The Action Agencies must reinitiate EFH consultation with NMFS if the action is substantially revised in a manner that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH conservation recommendations (50 CFR Section 600.920 [k]).

This page is intentionally left blank.

13.0 REINITIATION OF CONSULTATION

Consultation must be reinitiated if the amount or extent of taking specified in the incidental take statement is exceeded, or is expected to be exceeded; if new information reveals effects of the action may affect listed species in a way not previously considered; if the action is modified in a way that causes an effect on listed species that was not previously considered; or if a new species is listed or critical habitat is designated that may be affected by the action (50 CFR Section 402.16).

Except as specifically provided in the RPA, these general conditions apply as well to prospective agreements, plans, and contracts that the Action Agencies use to plan for operation of or to actually operate the FCRPS and BOR projects and to coordinate operations with Canada and regional utilities. Examples include implementation of the Columbia River Treaty between the United States and Canada, such as by the adoption of assured operating plans and detailed operating plans; arrangements with Canada for non-Treaty storage; and renewing and revising the Pacific Northwest Coordination Agreement.

To the extent that the prospective agreements are used to achieve operations that are in accordance with this biological opinion, including its RPA, reasonable and prudent measures, and terms and conditions, the effects of those prospective agreements on listed fish have been considered in this biological opinion. To the extent that proposed agreements have effects on FCRPS or BOR operations that affect listed fish in ways not considered in this biological opinion, or have provisions that go beyond implementing the operations specified in the opinion, those proposed actions may require separate consultation or reinitiation of this consultation.

In addition to the general conditions described above, the RPA in this biological opinion provides specific performance standards that, if not met, would result in a reinitiation of this consultation. These performance measures are described in Section 9.2, and the conditions governing reinitiation on the basis of performance are described in Section 9.5. NMFS will issue an RPA failure report if it determines that the performance standards have not been met; this will be the basis for a reinitiation of consultation.

The RPA recommended in this biological opinion also anticipates specific projects to provide offsite mitigation. Details of those projects will be provided in the annual plans required by Section 9.4. When the details are available, formal or informal supplemental consultation may be necessary to consider the effects of those projects and, if appropriate, authorize any incidental take. NMFS' finding letters that evaluate the annual plans will determine the necessity of additional consultation.

Similarly, the RPA requires BOR to provide supplemental biological assessments concerning certain of its irrigation projects that may have local effects on listed species. NMFS' consideration of this additional information may necessitate formal or informal supplemental consultation.

This page is intentionally left blank.

14.0 REFERENCES

Adams, N. S., and D. W. Rondorf. 1999. Migrational characteristics of juvenile chinook salmon in the forebay of Lower Granite Dam relative to the 1998 surface bypass collector tests. Annual Report (draft) of U.S. Geological Survey, Biological Resources Division, Cook, Washington, to U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

ASCE (American Society of Civil Engineers). 1995. Guidelines for design of intakes for hydroelectric plans. Committee on Hydropower Intakes of the Energy Division, ASCE, Reston, Virginia.

Barnes, C. A., C. Duxbury, and B. A. Morse. 1972. Circulation and selected properties of the Columbia River plume at sea. Pages 41-80 *in* A. T. Pruter and D. L. Alverson, editors. The Columbia River estuary and adjacent ocean waters. University of Washington Press, Seattle.

Barnthouse, L. W., A. Anganuzzi, L. Botsford, J. Kitchell, and S. Saila. 1994. Columbia basin salmonid model review: review of Biological Requirements Work Group report on analytical methods for determining requirements of listed Snake River salmon relative to survival and recovery. Oak Ridge National Laboratory, Oak Ridge, Tennessee. December.

Battelle and USGS (U.S. Geological Survey). 2000. Assessment of the impacts of development and operation of the Columbia River hydroelectric system on mainstem riverine processes and salmon habitats. Battelle Pacific Northwest Division, Richland, Washington, and USGS, Biological Resources Division, Cook, Washington.

Beamesderfer, R. C. 1992. Reproduction and early life history of northern squawfish, *Ptychocheilus oregonenesis*, in Idaho's St. Joe River. Environmental Biology of Fishes 35:231-241.

Beamesderfer, R. C., B. E. Rieman, L. J. Bledsoe, and S. Vigg. 1990. Management implications of a model of predation by a resident fish on juvenile salmonids migrating through a Columbia River reservoir. North American Journal of Fisheries Management 10:290-304.

Beamesderfer, R. C., D. L. Ward, and A. A. Nigro. 1996. Evaluation of the biological basis for a predator control program on northern squawfish (*Ptychocheilus oregonensis*) in the Columbia and Snake rivers. Canadian Journal of Fisheries and Aquatic Sciences 53:2898-2908.

Beckman, B. R., D. A. Larsen, C. Sharpe, B. Lee-Pawlak, C. B. Schreck, and W. W. Dickhoff. 2000. Physiological status of naturally reared juvenile spring chinook salmon in the Yakima River: seasonal dynamics and changes associated with smolting. Transactions of the American Fisheries Society 129:727-753.

Bell, M. C. 1991. Fisheries handbook of engineering requirements and biological criteria, fish passage and development program. U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon.

Bell, M. C., A. C. Delacy, G. J. Paulik, K. J. Bruya, and C. T. Scott. 1981. Updated compendium on the success of passage of small fish through turbines. Report to U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon.

Benner, P. A., and J. R. Sedell. 1997. Upper Willamette River landscape: a historic perspective. Pages 23-47 *in* A. Laenen and D. Dunnette, editors. River quality: dynamics and restoration. CRC Lewis Publishers, Boca Raton, Florida.

Bentley, W. W., and H. L. Raymond. 1976. Delayed migration of yearling chinook salmon since completion of Lower Monumental and Little Goose dams on the Snake River. Transactions of the American Fisheries Society 105:422-424.

Berggren, T. J., and M. J. Filardo. 1993. An analysis of variables influencing the migration of juvenile salmonids in the Columbia River basin. North American Journal of Fisheries Management 13:48-63.

Bevan, D., J. Harville, P. Bergman, T. Bjornn, J. Crutchfield, P. Klingeman, and J. Litchfield. 1994. Snake River Salmon Recovery Team: final recommendations to National Marine Fisheries Service. May.

Beyer, J. M., G. Lucchetti, and G. Gray. 1988. Digestive tract evacuation in northern squawfish (*Ptychocheilus oregonenesis*). Canadian Journal of Fisheries and Aquatic Sciences 45:548-553.

BioSonics. 1998. Hydroacoustic evaluation and studies at Bonneville Dam, spring/summer 1997. Volume 1: fish passage. Biosonics, Inc., Seattle, Washington, to U.S. Army Corps of Engineers, Portland District, Portland, Oregon.

Bjornn, T. C. 1989. An assessment of adult losses, production rates, and escapements for wild spring and chinook salmon in the Snake River. Pages 29-38 *in* D. L. Park, convenor. Status and future of spring chinook salmon in the Columbia River basin–conservation and enforcement. National Marine Fisheries Service, Northwest Fisheries Science Center, NOAA Technical Memorandum NMFS F/NWC-187 (1990), Seattle, Washington.

Bjornn, T. 1998. Fax re: chinook salmon passage times at Lower Granite Dam, 1996 and 1997, plotted against river flow and spill at the dam at the time fish entered the trailrace, to R. Kalamasz, S. Pettit, and J. Ceballos, from T. Bjornn, University of Idaho, Moscow. April 4.

Bjornn, T. 2000. Fax re: spill at Snake River dams, to J. Ceballos, National Marine Fisheries Service, from T. Bjornn, University of Idaho, Moscow. January 20.

Bjornn, T. C., J. P. Hunt, K. R. Tolotti, P. J. Keniry, and R. R. Ringe. 1995. Migration of adult chinook salmon and steelhead past dams and reservoirs in the lower Snake River and into tributaries – 1993. Technical Report 95-1 of Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, for U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington, and Bonneville Power Administration, Portland, Oregon.

Bjornn, T. C., M. L. Keefer, C. A. Peery, K. R. Tolotti, R. R. Ringe, and L. C. Stuehrenburg. 1999. Adult chinook and sockeye salmon, and steelhead fallback rates at Bonneville Dam – 1996, 1997, and 1998. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, for U.S. Army Corps of Engineers, Portland, Oregon.

Bjornn, T. C., and C. A. Peery. 1992. A review of literature related to movements of adult salmon and steelhead past dams and through reservoirs in the lower Snake River. Technical Report 92-1 of Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, for U.S. Army Corps of Engineers.

Bjornn. T. C., K. R. Tolotti, J. P. Hunt, P. J. Keniry, R. R. Ringe, and C. A. Peery. 1998. Passage of chinook salmon through lower Snake River and distribution into the tributaries, 1991 – 1993. Part 1. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, for U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

Blankenship, H. L., and G. W. Mendel, editors. 1997. Upstream passage, spawning, and stock identification of fall chinook salmon in the Snake River, 1992. Annual Report of Washington Department of Fisheries to Bonneville Power Administration, Portland, Oregon.

BOR (U.S. Bureau of Reclamation). 1999a. Biological assessment on operations of the Federal Columbia River Power System for 2000 and beyond. Appendix A: description of Bureau of Reclamation projects in the Columbia River basin. BOR, Pacific Northwest Region, Boise, Idaho. December.

BOR (U.S. Bureau of Reclamation). 1999b. Cumulative effects of water use: an estimate of the hydrologic impacts of water resource development in the Columbia River basin. Cumulative hydrologic effects of water use: an estimate of the hydrologic impacts of water resource development in the Columbia River basin. BOR, Pacific Northwest Region, Final Report, Boise, Idaho. June.

BOR (U.S. Bureau of Reclamation). 2000a. Untitled (water use upstream from McNary Dam). QuattroPro spreadsheet 500irrusewithstorage.wb3. J. Peterson, BOR, Pacific Northwest Division, Boise, Idaho. May 3.

BOR (U.S. Bureau of Reclamation). 2000b. Untitled (water use downstream from McNary Dam). QuattroPro spreadsheet 500irrusewithstoragebelowmcnary.qpw. J. Peterson, BOR, Pacific Northwest Division, Boise, Idaho. May 20.

BOR (U.S. Bureau of Reclamation). 2000c. Memorandum re: consultation on project water quality impacts, to K. Predde, BOR, from D. Zimmer, BOR, Pacific Northwest Division, Boise, Idaho. April 25.

BOR (U.S. Bureau of Reclamation). 2000d. Letter re: treatment of Reclamation's Snake River projects in biological opinions, to B. Brown, National Marine Fisheries Service, Portland, Oregon, and W. Shake, U.S. Fish and Wildlife Service, Portland, Oregon, from J. W. McDonald, BOR, Pacific Northwest Region, Boise, Idaho.

Botsford, L. 1997. Depensation, performance standards, and probabilities of extinction for Columbia spring/summer chinook salmon. *In* D. Marmorek and C. Peters, editors. Plan for analyzing and testing hypotheses (PATH): retrospective and prospective analyses of spring/summer chinook reviewed in FY 1997. ESSA Technologies, Ltd. Vancouver, B.C.

Botsford, L. W., and J. G. Brittnacher. 1997. Viability of Sacramento River winter-run chinook salmon. Conservation Biology 12(1):65-79.

Bottom, D. L., P. J. Howell, and J. D. Rodgers. 1985. The effects of stream alterations on salmon and trout habitat in Oregon. Oregon Department of Fish and Wildlife, Portland.

Bottom, D. L., and K. K. Jones. 1990. Community structure, distribution, and invertebrate prey of fish assemblages in the Columbia River estuary. Progressive Oceanography 25:211-241.

Bottom, D., S. Simenstad, A. Baptista, D. Jay, J. Burke, E. Casillas, K. Jones, and M. Schiewe. 2000. Estuarine influence on the recovery and resilience of Columbia River salmonids. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington, to Bonneville Power Administration, Portland, Oregon.

BPA (Bonneville Power Administration). 1993. Modified streamflows, 1990 level of irrigation, Columbia River and coastal basins, 1928-1989. A.G. Crook Company for BPA, Portland, Oregon.

BPA (Bonneville Power Administration). 2000a. Fifty-year continuous FELCC study results and documentation: Hydrosim run FISHOPS 0Y00.00FSH30.OPER. BPA, Portland, Oregon. December 1.

BPA (Bonneville Power Administration). 2000b. Fifty-year continuous FELCC study results and documentation: Hydrosim run FISHOPS 0Y00.00FSH33wo.OPER BPA, Portland, Oregon. December 1.

BPA (Bonneville Power Administration), BOR (U.S. Bureau of Reclamation), and Corps (U.S. Army Corps of Engineers). 1999. Multi-species biological assessment of the Federal Columbia River Power System. BPA, BOR, and Corps to National Marine Fisheries Service and U.S. Fish and Wildlife Service, Portland, Oregon. December 21.

BRT (Biological Review Team). 1997. Status review update for West Coast steelhead from Washington, Idaho, Oregon, and California. National Marine Fisheries Service, West Coast Steelhead BRT, Portland, Oregon.

Bugert, R., P. LaRiviere, D. Marbach, S. Martin, L. Ross, and D. Geist. 1990. 1989 Annual Report of Lower Snake River Compensation Plan, Salmon Hatchery Evaluation Program, to U.S. Fish and Wildlife Service (Cooperative Agreement 14-16-0001-89525).

Burley, C. C., and T. P. Poe, editors. 1994. Significance of predation in the Columbia River from Priest Rapids Dam to Chief Joseph Dam. U.S. Geological Survey, Western Fisheries Research Center, Seattle, Washington, for Mid-Columbia Public Utility Districts.

Burner, C. J. 1951. Characteristics of nests of Columbia River salmon. Fisheries Bulletin 61:97-110.

Busack, C. 1991. Genetic evaluation of the Lyons Ferry Hatchery stock and wild Snake River fall chinook. Washington Department of Fisheries, Report to ESA Administrative Record for Fall Chinook Salmon, Olympia. May.

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. J. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status review of West Coast steelhead from Washington, Idaho, Oregon, and California. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Busby, P., and 10 co-authors. 1999. Updated status of the review of the Upper Willamette River and Middle Columbia River ESUs of steelhead (*Oncorhynchus mykiss*). National Marine Fisheries Service, Northwest Fisheries Science Center, West Coast Biological Review Team, Seattle, Washington.

Casillas, E. 1999. Role of the Columbia River estuary and plume in salmon productivity. NWPPC Ocean Symposium, July 1, 1999. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Casillas, E., L. Crockett, Y. deReynier, J. Glock, M. Helvey, B. Meyer, C. Schmitt, M. Yoklavich, A. Bailey, B. Chao, B. Johnson, and T. Pepperell. 1998. Essential fish habitat, West Coast groundfish appendix. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

CBFWA (Columbia Basin Fish and Wildlife Authority). 1990. Snake River subbasin (mainstem from mouth to Hells Canyon Dam) salmon and steelhead production plan. CBFWA, Northwest Power Planning Council, Portland, Oregon.

Chandler, J. A. 1993. Consumption rates and estimated total loss of juvenile salmonids by northern squawfish in Lower Granite Reservoir, Washington. Master's thesis. University of Idaho, Moscow.

Chapman, D., A. Giorgi, M. Hill, A. Maule, S. McCutcheon, D. Park, W. Platts, K. Prat, J. Seeb, L. Seeb, and others. 1991. Status of Snake River chinook salmon. Don Chapman Consultants, Inc., Boise, Idaho, for Pacific Northwest Utilities Conference Committee.

Chapman, D., C. Peven, A. Giorgi, T. Hillman, and F. Utter. 1995. Status of spring chinook salmon in the mid-Columbia River. Don Chapman Consultants, Inc., Boise, Idaho.

Chapman, D., C. Pevan, T. Hillman, A. Giorgi, and F. Utter. 1994. Status of summer steelhead in the mid-Columbia River. Don Chapman Consultants, Inc., Boise, Idaho.

Chilcote, M. W. 1997. Conservation status of steelhead in Oregon. Oregon Department of Fish and Wildlife, Draft Report, Portland. September 9.

Collis, K., S. Adamany, D. D. Roby, D. P. Craig, and D. E. Lyons. 1999. Avian predation on juvenile salmonids in the lower Columbia River. Report to Bonneville Power Administration and U.S. Army Corps of Engineers. Columbia River Inter-Tribal Fish Commission, Portland, Oregon, and Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, Corvallis. October.

Columbia Bird Research. 2000. Avian predation project update, draft season summary. <*http://www.columbiabirdresearch.org*> (accessed November 11).

Connor, W. P., H. L. Burge, and D. H. Bennett. 1998. Detection of PIT-tagged subyearling chinook salmon at a Snake River dam: implications of summer flow augmentation. North American Journal of Fisheries Management 18:530-536.

Connor, W. P., R. K. Steinhorst, and H. L. Burge. 1999. Seaward migration by subyearling chinook salmon in the Snake River. Chapter 7 *in* K. F. Tiffan, D. W. Rondorf (U.S. Geological Survey, Cook, Washington), W. P. Connor, and H. L. Burge (U.S. Fish and Wildlife Service, Ahsahka, Idaho). Identification of the spawning, rearing, and migratory requirements of fall chinook salmon in the Columbia River basin. Annual report 1996-1997 (Project 91-029) to Bonneville Power Administration, Portland, Oregon,

Cooney, T. D. 2000. UCR steelhead and spring chinook salmon quantitative analysis report. Part 1: run reconstructions and preliminary assessment of extinction risk. National Marine Fisheries Service, Hydro Program, Technical Review Draft, Portland, Oregon. December 20.

Coronado, C., and R. Hilborn. 1998a. Spatial and temporal factors affecting survival in coho and fall chinook salmon in the Pacific Northwest. Bulletin of Marine Science 62(2):409-425.

Coronado, C., and R. Hilborn. 1998b. Spatial and temporal factors affecting survival in coho salmon (*Oncorhynchus kisutch*) in the Pacific Northwest. Canadian Journal of Fisheries and Aquatic Sciences 55:2067-2088.

Corps (U.S. Army Corps of Engineers). 1978. Bonneville lock and dam, Oregon and Washington, feasibility report and hydraulic model studies. Corps, Portland District, Portland, Oregon.

Corps (U.S. Army Corps of Engineers). 1984. Columbia River basin master water control manual. Corps, North Pacific Division, Portland, Oregon. December.

Corps (U.S. Army Corps of Engineers). 1989. Annual fish passage report, Columbia and Snake river projects. Corps, Portland District, Portland, Oregon, and Walla Walla District, Walla Walla, Washington.

Corps (U.S. Army Corps of Engineers). 1991. Review of flood control Columbia River basin–Columbia River and tributaries study, CRT 63. U.S. Army Corps of Engineers, North Pacific Division. June.

Corps (U.S. Army Corps of Engineers). 1995. Bonneville Second Powerhouse, juvenile fish sampling and monitoring facility. Corps, Portland District, Feature Design Memorandum 43, Portland, Oregon.

Corps (U.S. Army Corps of Engineers). 1996. Bonneville Second Powerhouse, downstream migrant system improvements, 90% review. Corps, Portland District, Supplement 6 to Design Memorandum 9, Portland, Oregon.

Corps (U.S. Army Corps of Engineers). 1997. Columbia River basin, system flood control review: preliminary analysis report. Corps, North Pacific Division, Portland, Oregon. February.

Corps (U.S. Army Corps of Engineers). 1999a. Bonneville First Powerhouse, juvenile bypass system improvements. Corps, Portland District, Supplement 2 to Design Memorandum 37, Portland, Oregon.

Corps (U.S. Army Corps of Engineers). 1999b. Columbia River Treaty, flood control operating plan. Corps, Northwestern Division, North Pacific Region, Portland, Oregon. October.

Corps (U.S. Army Corps of Engineers). 1999c. Lower Snake River juvenile salmon migration feasibility report/environmental impact statement. Corps, Walla Walla District, Draft Report, Walla Walla, Washington. December.

Corps (U.S. Army Corps of Engineers). 1999d. Work to date on the development of the VARQ flood control operation at Libby Dam and Hungry Horse Dam. Corps, Northwestern Division, North Pacific Region, Status Report, Portland, Oregon. January.

Corps (U.S. Army Corps of Engineers). 1999e. Fish passage plan for Corps of Engineers projects. U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon. February.

Corps (U.S. Army Corps of Engineers). 2000a. Tailwater rating curve for Columbia River at Bonneville Dam. Corps, Portland District, Portland, Oregon, to National Marine Fisheries Service, Hydro Program, Portland, Oregon. January.

Corps (U.S. Army Corps of Engineers). 2000b. Salmon recovery through John Day Reservoir: John Day drawdown phase 1 study. Corps, Portland District, Draft Report, Portland, Oregon. January.

Coutant, C. C. 1999. Perspectives on temperature in the Pacific Northwest's fresh waters. Oak Ridge National Laboratory, Environmental Sciences Division, Publication 4849, Oak Ridge, Tennessee.

Cramer, S. P., J. Norris, P. Mundy, G. Grette, K. O'Neal, J. Hogle, C. Steward, and P. Bahls. 1999. Status of chinook salmon and their habitat in Puget Sound, volume 2. S. P. Cramer and Associates, Inc., Final Report, Gresham, Oregon.

CREDDP (Columbia River Estuary Data Development Program). 1980. Volume 1: summary plus maps. Volume 2: annotated bibliography. Pacific Northwest River Basins Commission, Vancouver, Washington.

Cudaback, C. N., and D. A. Jay. 1996. Buoyant plume formation at the mouth of the Columbia River – an example of internal hydraulic control? buoyancy effects on coastal and estuarine dynamics. Coastal and Estuarine Studies 53:139-154.

Curet, T. S. 1993. Habitat use, food habits and the influence of predation on subyearling chinook salmon in Lower Granite and Little Goose reservoirs, Washington. Master's thesis. University of Idaho, Moscow. December.

Dauble, D .D., R. L. Johnson, and A. Garcia. 1999. Fall chinook spawning in tailraces of lower Snake River hydroelectric projects. Transactions of the American Fisheries Society 128:672-697.

Dawley, E. M., L. G. Gilbreath, R. F. Absolon, B. P. Sandford, and J. W. Ferguson. 1999. Relative survival of juvenile salmonids passing through the spillway and ice and trash sluiceway of The Dalles Dam, 1998. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington, to U.S. Army Corps of Engineers.

Dawley, E. M., R. D. Ledgerwood, T. H. Blahm, C. W. Sims, J. T. Durkin, R. A. Kirn, A. E. Rankis, G. E. Moran, and F. J. Ossiander. 1986. Migrational characteristics, biological observations, and relative survival of juvenile salmonids entering the Columbia River estuary, 1966-1983. Final Report of National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington, to Bonneville Power Administration, Portland, Oregon.

Dees, L. T. 1961. Cephalopods: cuttlefish, octopuses, squids. U.S. Department of the Interior, Bureau of Commercial Fisheries, Fishery Leaflet 524.

Dennis, B., P. L. Munholland, and J. M. Scott. 1991. Estimation of growth and extinction parameters for endangered species. Ecological Monographs 61(12):115-143.

Deriso, R., D. Marmorek, and I. Parnell. 1996. Retrospective analysis of passage mortality of spring chinook of the Columbia River. Chapter 5 *in* D. Marmorek, editor. Plan for analyzing and testing hypotheses (PATH): final report on retrospective analysis for fiscal year 1996. ESSA Technologies Ltd., Vancouver, B.C. September 10.

Doppelt, B., M. Scurlock, C. Frissell, and J. Karr. 1993. Entering the watershed: a new approach to save America's river ecosystems. Island Press, Washington, D.C.

Ebel, W. J., and H. L. Raymond. 1976. Effect of atmospheric gas supersaturation on salmon and steelhead rivers. U.S. National Marine Fisheries Service, Marine Fisheries Review 38:1-14

Eicher. 1987. Turbine-related fish mortality: review and evaluation of studies. Eicher Associates, Inc., to Electric Power Research Institute, Palo Alto, California.

Elston, R. J. 1996. Investigation of head burns in adult salmonids. Phase 1: examination of fish at Lower Granite Dam. Bonneville Power Administration, Final Report (Project 96-050-00), Portland, Oregon. July 2.

Emmett, R. L., S. L. Stone, S. A. Hinton, and M. E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in West Coast estuaries. Volume 2: species life history summaries. NOAA/NOS Strategic Environmental Assessments Division, ELMR Report 8, Rockville, Maryland.

Eppard, M. B., G. A. Axel, B. P. Sandford, and D. B. Dey. 2000. Effects of spill on the passage of hatchery yearling chinook salmon at Ice Harbor Dam, 1999. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington, to U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

Eschmeyer, W. N., E. S. Herald, and H. Hamman. 1983. A field guide to Pacific coast fishes of North America. Houghton Mifflin Company, Boston, Massachusetts.

Evans, A. F., and R. E. Beaty. 2000. Identification and enumeration of steelhead (*Oncorhynchus mykiss*) kelts in the juvenile collection systems at Lower Granite and Little Goose dams, 2000. *In* U.S. Army Corps of Engineers. Anadromous fish evaluation program: 2000 annual research review. Portland District, Portland, Oregon, and Walla Walla District, Walla Walla, Washington.

Evermann, B. W. 1895. A preliminary report upon salmon investigations in Idaho in 1894. U.S. Fish Commission Bulletin 15:253-284.

Faler, M. P., L. M. Miller, and K. I. Welke. 1988. Effects of variation in flow on distribution of northern squawfish in the Columbia River below McNary Dam. North American Journal of Fisheries Management 8:30-35.

Falter, C. M. 1969. Digestive rates and daily rations of northern squawfish in the St. Joe River, Idaho. Doctoral dissertation. University of Idaho, Moscow.

Federal Caucus. 2000. Conservation of Columbia basin fish: final basinwide salmon recovery strategy. <*http://www.salmonrecovery.gov*> December.

Fields, W. G. 1965. The structure, development, food relations, reproduction and life history of the squid (*Loligo opalescens* Berry). California Department of Fish and Game, Fish Bulletin 131.

Fish Passage Center. 2000. Adult salmon passage counts. FPC (Fish Passage Center) Home. <*http:www.fpc.org/adlthist/prdadult.htm*> December 16.

Flagg, T. A., and C. E. Nash, editors. 1999. A conceptual framework for conservation hatchery strategies for Pacific salmonids. National Marine Fisheries Service, Northwest Fisheries Science Center, NOAA Technical Memorandum NMFS-NWFSC-38, Seattle, Washington.

Flagg, T. A., F. W. Waknitz, D. J. Maynard, G. B. Milner, and C.V.W. Mahnken. 1995. The effect of hatcheries on native coho salmon populations in the lower Columbia River. *In* Uses and effects of cultured fishes in aquatic systems. Transactions of the American Fisheries Society 15:366-375.

Ford, M., P. Budy, C. Busack, D. Chapman, T. Cooney, T. Fisher, J. Geiselman, T. Hillman, J. Lukas, C. Peven, C. Toole, E. Weber, and P. Wilson. 1999. UCR steelhead and spring chinook salmon population structure and biological requirements. National Marine Fisheries Service, Northwest Fisheries Science Center, Upper Columba River Steelhead and Spring Chinook Salmon Biological Requirements Committee, Draft Report, Seattle, Washington. November 23.

FPAC (Fish Passage Advisory Committee). 1999. System operational request 99-28 re: flows at Bonneville Dam. FPAC of Columbia Basin Fish and Wildlife Authority, Portland, Oregon. September 3.

Francis, R. C., and S. R. Hare. 1994. Decadal-scale regime shifts in the large marine ecosystems of the North-east Pacific: a case for historical science. Fisheries Oceanography 3(4)279-291.

Franklin, J. F., and C. T. Dyrness. 1973. Natural vegetation of Oregon and Washington. U.S. Department of Agriculture, Pacific Northwest Forest and Range Experiment Station, USDA Forest Service General Technical Report PNW-8, Portland, Oregon.

Friesen, T. A., and D. L. Ward. 1999. Management of northern squawfish and implications for juvenile survival in the lower Columbia and Snake rivers. North American Journal of Fisheries Management 19:406-420.

Frissell, C. A. 1993. A new strategy for watershed restoration and recovery of Pacific salmon in the Pacific Northwest. Prepared for Pacific Rivers Council, Eugene, Oregon.

Fulton, L. A. 1968. Spawning areas and abundance of chinook salmon, *Oncorhynchus tshawytscha*, in the Columbia River basin – past and present. U.S. Fish and Wildlife Service, Special Scientific Report, Fisheries 571:26.

Fulton, L. A. 1970. Spawning areas and abundance of steelhead trout and coho, sockeye, and chum salmon in the Columbia River basin – past and present. U.S. Fish and Wildlife Service, Special Scientific Report, Fisheries 618.

Gadomski, D. M., M. G. Mesa, and T. M. Olson. 1994. Vulnerability to predation and physiological stress responses of experimentally descaled juvenile chinook salmon, *Oncorhynchus tshawytscha*. Environmental Biology of Fishes 39:191-199.

Geist, D. 2000. PNNL objectives – FY00. Handout at meeting with fisheries comanagers. Pacific Northwest National Laboratory, Richland, Washington. February 16.

Giorgi, A. 1996. Spill effectiveness/efficiency: scooping the information. PATH Task 3.1.4a. Appendix 4 of Chapter 6 *in* D. Marmorek, editor. Plan for analyzing and testing hypotheses (PATH): final report on retrospective analyses for fiscal year 1996. ESSA Technologies Ltd., Vancouver, B.C.

Gotshall, D. W. 1977. Fishwatchers' guide to the inshore fishes of the Pacific coast. Sea Challengers, Monterey, California.

Graves, R. 1998. Memo to Hydro Program files re: 1998 transportation estimates, results from discussions with T. Berggren, Fish Passage Center. National Marine Fisheries Service, Hydro Program, Portland, Oregon. October 6.

Gray, G. A., and D. W. Rondorf. 1986. Predation on juvenile salmonids in Columbia Basin reservoirs. Pages 178-185 *in* G. E. Hall and M. J. Van Den Avyle, editors. Reservoir fisheries management strategies for the '80s. American Fisheries Society, Southern Division, Reservoir Committee, Bethesda, Maryland.

Gregory, R. S. 1993. Effect of turbidity on the predator avoidance behavior of juvenile chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 50:241-246.

Gregory, R. S., and C. D. Levings. 1998. Turbidity reduces predation on migrating juvenile Pacific salmon. Transactions of the American Fisheries Society 127:275-285.

Groot, C., L. Margolis, and W. C. Clarke. 1995. Physiological ecology of Pacific salmon. University of British Columbia Press, Vancouver, B.C.

Gustafson, R. G., T. C. Wainwright, G. A. Winans, F. W. Waknitz, L. T. Parker, and R. S. Waples. 1997. Status review of sockeye salmon from Washington and Oregon. National Marine Fisheries Service, Northwest Fisheries Science Center, NOAA Technical Memorandum NMFS-NWFSC-33, Seattle, Washington.

Haertel, L., C. Oserberg, H. Curl, Jr., and P. K. Park. 1969. Nutrient and plankton ecology of the Columbia River estuary. Ecology 50:962-978.

Hansel, H. C., N. S. Adams, T. D. Counihan, B. D. Liedtke, M. S. Novick, J. M. Plumb, and T. P. Poe. 1999. Estimates of fish and spill passage efficiency for radio-tagged juvenile steelhead and yearling chinook salmon at John Day Dam, 1999. Annual Report of Research by U.S. Geological Survey, Biological Resources Division, Cook, Washington, to U.S. Army Corps of Engineers, Portland District, Portland, Oregon.

Hare, S. R., N. J., Mantua, and R. C. Francis. 1999. Inverse production regimes: Alaskan and West Coast Pacific salmon. Fisheries 21:6-14.

Harmon, J. R., D. J. Kamikawa, B. P. Sandford, K. W. McIntyre, K. L. Thomas, N. N. Paasch, and G. M. Matthews. 1995. Research related to transportation of juvenile salmonids on the Columbia and Snake rivers, 1993. National Marine Fisheries Service, Northwest and Alaska Fisheries Center, Coastal Zone and Estuarine Studies Division, Seattle, Washington.

Harmon, J. R., K. L. Thomas, K. W. McIntyre, and N. N. Paasch. 1994. Prevalence of marine-mammal tooth and claw abrasions on adult anadromous salmonids returning to the Snake River. North American Journal of Fisheries Management 14:661-663.

Hart, J. L. 1973. Pacific fisheries of Canada. Fisheries Research Board of Canada Bulletin 180:199-221.

Harza. 2000. Salmon spawning habitat evaluation. Final Report by Harza Engineering Company, Portland, Oregon, to Bonneville Power Administration, Portland, Oregon.

Hassemer, P. F. 1992. Run composition of the 1991-92 run-year Snake River steelhead measured at Lower Granite Dam. Idaho Fish and Game, Boise, to National Oceanic and Atmospheric Administration (Award NA90AA-D-IJ718).

Healey, M. C. 1983. Coastwide distribution and ocean migration patterns of stream- and ocean-type chinook salmon, *Oncorhynchus tshawytscha*. Canadian Field-Naturalist 97:427-433.

Healey, M. C. 1991. Life history of chinook salmon (*Oncorhynchus tshawytscha*). Pages 311-393 *in* Groot, C. and L. Margolis, editors. Pacific salmon life histories. University of British Columbia Press, Vancouver, B.C.

Henjum, M. G., J. R. Karr, D. L. Bottom, D. A. Peery, J. C. Bednarz, S. G. Wright, S. A. Beckwitt, and E. Beckwitt. 1994. Interim protection for late-successional forests, fisheries, and watersheds: national forests east of the Cascade Crest, Oregon, and Washington. The Wildlife Society, Bethesda, Maryland.

Hinton, S. A., and R. L. Emmett. 1994. Juvenile salmonid stranding in the lower Columbia River, 1992 and 1993. National Marine Fisheries Service, Northwest Fisheries Science Center, NOAA Technical Memorandum NMFS-NWFSC-20, Seattle, Washington. December.

Hockersmith, E. E., S. G. Smith, W. D. Muir, B. P. Sandford, J. G. Williams, and J. R. Skalski. 1999. Survival estimates for the passage of juvenile salmonids through Snake River dams and reservoirs. National Marine Fisheries Service, Northwest Science Center, Seattle, Washington, to Bonneville Power Administration, Portland, Oregon (Project 93-29).

Holmes, E. E. In review. Estimating risks for declining populations: salmonids as an example. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. Submitted to Ecological Applications.

Holmes, H. B. 1952. Loss of salmon fingerlings in passing Bonneville Dam as determined by marking experiments. Unpublished manuscript, U.S. Bureau of Commercial Fisheries. U.S. Fish and Wildlife Service, Vancouver, Washington, to U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon.

Howell, P., K. Jones, D. Scarnecchia, L. LaVoy, W. Knedra, and D. Orrmann. 1985. Stock assessment of Columbia River anadromous salmonids, 2 volumes. Final Report to Bonneville Power Administration, Portland, Oregon (Project 83-335).

Hurson, D., and 17 coauthors. 1996. Juvenile fish transportation program. U.S. Army Corps of Engineers, Walla Walla District, 1994 Annual Report, Walla Walla, Washington.

Hymer, J. 1999a. Hardy Creek. E-mail. Washington Department of Fisheries, Vancouver. October 20.

Hymer, J. 1999b. Question about tules below Bonneville. E-mail. Washington Department of Fisheries, Vancouver. October 20.

Irving, J. S., and T. C. Bjornn. 1981. Status of Snake River fall chinook salmon in relation to the Endangered Species Act. Idaho Cooperative Fishery Research Unit, University of Idaho, Moscow, for U.S. Fish and Wildlife Service.

ISAB (Independent Scientific Advisory Board). 1998. Review of artificial production of anadromous and resident fish in the Columbia River basin. Part 1: a scientific basis for Columbia River production programs. ISAB, Report 98-33, for Northwest Power Planning Council and National Marine Fisheries Service, Portland, Oregon. December.

ISAB (Independent Scientific Advisory Board). 1999. Review of the National Marine Fisheries Service draft cumulative risk analysis addendum "An assessment of lower Snake River hydrosystem alternatives on survival and recovery of Snake River salmonids." ISAB, Report 99-6, for Northwest Power Planning Council and National Marine Fisheries Service, Portland, Oregon. October 12.

ISAB (Independent Scientific Advisory Board). 2000. Letter re: spill levels at The Dalles Dam, to W. D. McConnaha, Northwest Power Planning Council, Portland, Oregon, and M. Schiewe, National Marine Fisheries Service, Seattle, Washington, from J. Lichatowich, ISAB, Portland, Oregon. February 15.

ISG (Independent Science Group). 1996. Return to the river: restoration of salmonid fishes in the Columbia River ecosystem. ISG, Report 96-6, for Northwest Power Planning Council, Portland, Oregon.

IUCN (International Union for the Conservation of Nature and Natural Resources). 2000. The 2000 IUCN red list of threatened species: 1994 categories and criteria. <http://www.redlist.org/categories_criteria.html> (accessed October 24).

Iwamoto, R. N., and J. G. Williams. 1993. Juvenile salmonid passage and survival through turbines. Report to U.S. Army Corps of Engineers, Portland, Oregon.

Jackson, P. L. 1993. Climate. Pages 48-57 *in* P. L. Jackson and A. J. Kimerling, editors. Atlas of the Pacific Northwest. Oregon State University Press, Corvallis.

Johnson, O. W., W. S. Grant, R. G. Kope, K. Neely, F. W. Waknitz, and R. S. Waples. 1997. Status review of chum salmon from Washington, Oregon, and California. National Marine Fisheries Service, Northwest Fisheries Science Center, NOAA Technical Memorandum NMFS-NWFSC-32, Seattle, Washington.

Jones, K., C. A. Simenstad, D. L. Higley, and D. L. Bottom. 1990. Community structure, distribution, and standing stock of benthos, epibenthos, and plankton in the Columbia River estuary. Progress in Oceanography 25:211-241.

Kareiva, P., M. Marvier, and M. McClure. 2000. Recovery and management options for spring/summer chinook salmon in the Columbia River basin. Science 290:977-979.

Karr, M. H., J. K. Fryer, and P. R. Mundy. 1998. Snake River water temperature control project – phase II. Methods for managing and monitoring water temperatures in relation to salmon in the lower Snake River. Columbia River Inter-Tribal Fish Commission, Portland, Oregon.

Keefer, M. L., and T. C. Bjornn. 1999. Evaluation of adult salmon and steelhead migrations past dams and through reservoirs in the Columbia River basin. *In* U.S. Army Corps of Engineers. Anadromous fish evaluation program: 1999 annual research review. Walla Walla District, Walla Walla, Washington.

Keeley, E. R., P. A. Slaney, and D. Zaldokas. 1996. Estimates of production benefits for salmonid fishes from stream restoration initiatives. Ministry of Environment, Lands, and Parks and Ministry of Forests, Watershed Restoration Management Report 4, Victoria, B.C.

Kostow, K, editor. 1995. Biennial report on the status of wild fish in Oregon. Oregon Department of Fish and Wildlife, Internal Report, Portland.

Krcma, R. F., G. A. Swan, and F. J. Ossiander. 1985. Fish guiding and orifice passage efficiency tests with subyearling chinook salmon, McNary Dam, 1984. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington, to U.S. Army Corps of Engineers.

Kuehl, E. S. 1986. Hydroacoustic evaluation of fish collection efficiency at Lower Granite Dam in spring, 1985. Biosonics, Inc., Seattle, Washington, to U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

Ledgerwood, D. L., E. M. Dawley, L. G. Gilbreath, P. J. Bently, B. P. Sandford, and M. H. Schiewe. 1990. Relative survival of subyearling chinook salmon which have passed Bonneville Dam via the spillway or the Second Powerhouse turbines or bypass system in 1989, with comparisons to 1987 and 1988. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington, to U.S. Army Corps of Engineers.

Ledgerwood, R. D., E. M. Dawley, L. G. Gilbreath, L. T. Parker, B. P. Sandford, and S. J. Grabowski. 1994. Relative survival of subyearling chinook salmon at Bonneville Dam, 1992. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington, to U.S. Army Corps of Engineers.

Leslie, P. H. 1945. On the use of matrices in certain population mathematics. Biometrika 33:183-212.

Leslie, P. H. 1948. Some further notes on the use of matrices in population mathematics. Biometrika 35:213-245.

Ligon, F. K., W. E. Dietrich, and W. J. Trush. 1995. Downstream ecological effects of dams: a geomorphic perspective. Bioscience 45:183-192.

Long, J. B., and L. E. Griffin. 1937. Spawning and migratory habits of the Columbia River steelhead trout as determined by scale studies. Copeia 31:62.

LCREP (Lower Columbia River Estuary Program). 1999. Comprehensive Conservation and Management Plan. Volume 1: June 1999. LCREP, Portland, Oregon.

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78:1069-1079.

Marmorek, D. R., and C. N. Peters, editors. 1998. Plan for analyzing and testing hypotheses (PATH): preliminary decision analysis report on Snake River spring/summer chinook. ESSA Technologies Ltd., Vancouver, B.C.

Marmorek, D. R., C. N. Peters, and I. Parnell, editors. 1998. Plan for analyzing and testing hypotheses (PATH): final report for fiscal year 1998. ESSA Technologies Ltd., Vancouver, B.C.

Marr, J. C. 1943. Age, length, and weight studies of three species of Columbia River salmon (*Oncorhynchus keta, O. gorbuscha* and *O. kisutch*). Stanford Ichthyological Bulletin 2:157-197.

Martinson, R. D., R. Graves, R. Mills, and J. Kamps. 1997. Monitoring of downstream salmon and steelhead at federal hydroelectric facilities – 1996. National Marine Fisheries Service, Hydro Program, Portland, Oregon, to Bonneville Power Administration, Portland, Oregon (Project 84-014).

Mattson, C. R. 1948. Spawning ground studies of Willamette River spring chinook salmon. Fish Commission of Oregon Research Briefs 1(2):21-32.

McClure, M. 2000. Alternative lambda (annual population growth rate) calculations. E-mail to C. Toole and B. Brown, National Marine Fisheries Service, Hydro Program, Portland, Oregon, from M. McClure, National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. December 2.

McClure, M., B. Sanderson, E. Holmes, C. Jordan, P. Kareiva, and P. Levin. 2000a. A standardized quantitative analysis of the risks faced by salmonids in the Columbia River basin. National Marine Fisheries Service, Northwest Fisheries Science Center, Cumulative Risk Initiative, Draft Report, Seattle, Washington. April 7.

McClure, B. Sanderson, E. Holmes, C. Jordan, P. Kareiva, and P. Levin. 2000b. Revised Appendix B of standardized quantitative analysis of the risks faced by salmonids in the Columbia River basin. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. September.

McClure, M. M., B. L. Sanderson, E. E. Holmes, and C. E. Jordan. 2000c. A large-scale, multi-species risk assessment: anadromous salmonids in the Columbia River basin. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. Submitted to Ecological Applications.

McCullough, D. A. 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids with special reference to chinook salmon. Report to Environmental Protection Agency, Region 10, Seattle, Washington.

McElhany, P., M. Ruckelshaus, M. J. Ford, T. Wainwright, and E. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. National Marine Fisheries Service, Northwest Fisheries Science Center, Draft Report, Seattle, Washington. January 6.

McKenzie, D., D. Carlile, and D. Weitkamp. 1984. 1983 systems mortality study. Battelle Pacific Northwest Laboratories, Richland, Washington, for Chelan County PUD, Grant County PUD, and Douglas County PUD.

McKenzie, D., D. Weitkamp, T. Schadt, D. Carlile, and D. Chapman. 1983. 1982 systems mortality study. Battelle Pacific Northwest Laboratories, Richland, Washington, for Chelan County PUD, Grant County PUD, and Douglas County PUD.

McKernan, D. L,. and C. R. Mattson. 1950. Observations on pulp and paper effluents and the probable effects of this pollutant on the fisheries resources of the Willamette River in Oregon. Fish Commission of Oregon, Fish Commission Research Briefs 3(1):14-21.

Meacham, C. P., and J. H. Clark. 1979. Management to increase anadromous salmon production. Pages 377-386 *in* H. C. Clepper, editor. Predator-prey systems in fisheries management. Sport Fishing Institute, Washington, D.C.

Mendel, G., and D. Milks. 1995. Upstream passage and spawning of fall chinook salmon in the Snake River. Washington Department of Fish and Wildlife, Hatcheries Program, Olympia.

Mesa, M. G. 1994. Effects of multiple acute stressors on the predator avoidance ability and physiology of juvenile chinook salmon. Transactions of the American Fisheries Society 123:786-793.

Mesa, M. G., A. G. Maule, and C. B. Schreck. 2000. Interaction of infection with *Renibacterium salmoninarum* and physical stress in juvenile chinook salmon: physiological responses, disease progression, and mortality. Transactions of the American Fisheries Society 129:158-173.

Mesa, M. G., and T. M. Olsen. 1993. Prolonged swimming performance of northern squawfish. Transactions of the American Fisheries Society 122:1104-1110.

Miller, D. J., and R. N. Lea. 1972. Guide to the coastal marine fishes of California. California Department of Fish and Game, Fish Bulletin 157.

Monaco, M. E., D. M. Nelson, R. L. Emmett, and S. A. Hinton. 1990. Distribution and abundance of fishes and invertebrates in west coast estuaries. Volume 1: data summaries. Strategic Assessment Branch, NOS/NOAA, ELMR Report 4, Rockville, Maryland.

Montgomery Water Group. 1997. Columbia Basin project water supply, use and efficiency report. Prepared for East Columbia Basin Irrigation District, Quincy-Columbia Basin Irrigation District, South Columbia Basin Irrigation District, Grand Coulee Project Hydroelectric Authority. June.

Muir, W. D., S. G. Smith, J. G. Williams, and B. P. Sandford. In review. Survival of juvenile salmonids passing through bypass systems, turbines, and spillways with and without flow deflectors at Snake River dams. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Muir, W. D., S. G. Smith, E. E. Hockersmith, S. Achord, R. F. Absolon, P. A. Ocker, B. M. Eppard, T. E. Ruehle, J. G. Williams, R. N. Iwamoto, and J. R. Skalski. 1996. Survival estimates for the passage of yearling chinook salmon and steelhead through Snake River dams and reservoirs, 1995. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington, to Bonneville Power Administration, Portland, Oregon.

Muir, W. D., S. G. Smith, K. W. McIntyre, and B. P. Sandford. 1998. Project survival of juvenile salmonids passing through the bypass system, turbines, and spillways with and without flow deflectors at Little Goose Dam, 1997. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington, to U.S. Army Corps of Engineers.

Muir, W. D., S. G. Smith, E. E. Hockersmith, M. B. Eppard, W. P. Connor, T. Andersen, and B. D. Arnsberg. 1999. Fall chinook salmon survival and supplementation studies in the Snake River and lower Snake River reservoirs, 1997. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington, to Bonneville Power Administration, Portland, Oregon.

Muir, W. D., W. S. Zaugg, A. E. Giorgi, and S. McCutcheon. 1994. Accelerating smolt development and downstream movement in yearling chinook salmon with advanced photoperiod and increased temperatures. Aquaculture 123:387-399.

Mullan, J. W., A. Rockhold, and C. R. Chrisman. 1992a. Life histories and precocity of chinook salmon in the mid-Columbia River. Progressive Fish-Culturist 54:25-28.

Mullan, J. W., K. R. Williams, G. Rhodus, T. W. Hillman, and J. D. McIntyre. 1992b. Production and habitat of salmonids in mid-Columbia River tributary streams. U.S. Fish and Wildlife Service Monograph 1.

Myers, J. M., R. G. Kope, G. J. Bryant, L. J. Lierheimer, R. S. Waples, R. W. Waknitz, T. C. Wainwright, W. S. Grant, K. Neely, and S. T. Lindley. 1998. Status review of chinook salmon from Washington, Idaho, Oregon, and California. National Marine Fisheries Service, Northwest Fisheries Science Center, NOAA Technical Memorandum NMFS-NWFSC-35, Seattle, Washington.

NMFS (National Marine Fisheries Service). 1991a. Factors for decline: a supplement to the notice of determination for Snake River fall chinook salmon under the Endangered Species Act. NMFS, Protected Resources Division, Portland, Oregon. June.

NMFS (National Marine Fisheries Service). 1991b. Factors for decline: a supplement to the notice of determination for Snake River spring/summer chinook salmon under the Endangered Species Act. NMFS, Protected Resources Division, Portland, Oregon.

NMFS (National Marine Fisheries Service). 1995a. Biological opinion – reinitiation of consultation on 1994-1998 operation of the Federal Columbia River Power System and juvenile transportation program in 1995 and future years. NMFS, Hydro Program, Portland, Oregon.

NMFS (National Marine Fisheries Service). 1995b. Juvenile fish screen criteria. <*http://www.nwr.noaa.gov/1hydrop/nmfscrit1.htm*> NMFS, Hydro Program, Portland, Oregon.

NMFS (National Marine Fisheries Service). 1995c. Proposed recovery plan for Snake River salmon. NMFS, Protected Resources Division, Portland, Oregon.

NMFS (National Marine Fisheries Service). 1998. Supplemental biological opinion – operation of the Federal Columbia River Power System including the smolt monitoring program and the juvenile fish transportation program: a supplement to the biological opinion signed on March 2, 1995, for the same projects. NMFS, Hydro Program, Portland, Oregon.

NMFS (National Marine Fisheries Service). 1999a. Biological opinion on artificial propagation in the Columbia River basin – incidental take of listed salmon and steelhead from Federal and non-Federal hatchery programs that collect, rear, and release unlisted fish species. NMFS, Endangered Species Act Section 7 consultation. March 29.

NMFS (National Marine Fisheries Service). 1999b. Biological opinion – Bureau of Reclamation operations and maintenance of its projects in the Snake River basin above Lower Granite Dam: a supplement to the biological opinions signed on March 2, 1995, and May 14, 1998. NMFS, Northwest Region. December 9.

NMFS (National Marine Fisheries Service). 1999c. Biological opinion and incidental take statement on 1999 Treaty Indian and non-Indian fall season fisheries in the Columbia River basin. NMFS, Endangered Species Act Section 7 consultation. July 30.

NMFS (National Marine Fisheries Service). 2000a. Letter re: draft biological opinion, to D. Poganis (Corps), R. McKown (BOR), T. Lamb (BPA), F. Olney (USFWS), M. L. Soscia (EPA), F. Disheroon (Dept. of Justice), and D. Mecham (Dept. of Interior), from B. Brown, NMFS, Hydro Program, Portland, Oregon. May 17.

NMFS (National Marine Fisheries Service). 2000b. Draft biological opinion – operation of the Federal Columbia River Power System including the juvenile fish transportation program and the Bureau of Reclamation's 31 projects, including the entire Columbia Basin Project. NMFS, Hydro Program, Portland, Oregon. July 27.

NMFS (National Marine Fisheries Service). 2000c. Memorandum to Hydro Program files re: Bonneville and John Day dam mixed stock chinook FGEs, from G. Fredricks, NMFS, Hydro Program, Portland, Oregon. January 28.

NMFS (National Marine Fisheries Service). 2000d. Supplemental biological opinion – operation of the Federal Columbia River Power System including the juvenile fish transportation program: a supplement to the biological opinions signed on March 2, 1995, and May 14, 1998, for the same projects. NMFS, Hydro Program, Portland, Oregon. February 4.

NMFS (National Marine Fisheries Service). 2000e. White paper: passage of juvenile and adult salmonids past Columbia and Snake river dams. NMFS, Northwest Fisheries Science Center, Seattle, Washington. April.

NMFS (National Marine Fisheries Service). 2000f. White paper: predation on salmonids relative to the Federal Columbia River Power System. NMFS, Northwest Fisheries Science Center, Seattle, Washington. February.

NMFS (National Marine Fisheries Service). 2000g. White paper: salmon and steelhead hatcheries – the problems. NMFS, Sustainable Fisheries Division, Portland, Oregon. February 3.

NMFS (National Marine Fisheries Service). 2000h. White paper: salmonid travel time and survival related to flow in the Columbia River basin. NMFS, Northwest Fisheries Science Center, Seattle, Washington. March.

NMFS (National Marine Fisheries Service). 2000i. White paper: summary of research related to transportation of juvenile anadromous salmonids around Snake and Columbia river dams. NMFS, Northwest Fisheries Science Center, Seattle, Washington. March.

NRC (National Research Council). 1996. Upstream: salmon and society in the Pacific Northwest. NRC, Report of the Committee on Protection and Management of the Pacific Northwest Anadromous Salmonids, Board on Environmental Studies and Toxicology, and Commission on Life Sciences. National Academy Press, Washington, D.C.

NWPPC (Northwest Power Planning Council). 1984. Columbia River basin fish and wildlife program. NWPPC, Portland, Oregon.

NWPPC (Northwest Power Planning Council). 1986. Compilation of information on salmon and steelhead losses in the Columbia River basin. Appendix D *in* 1987 Columbia River basin fish and wildlife program. NWPPC, Portland, Oregon. March.

NWPPC (Northwest Power Planning Council). 1987. Columbia River Basin Fish and Wildlife Program–compilation of information on salmon and steelhead losses in the Columbia River basin. Appendix D. NWPPC, Portland, Oregon.

NWPPC (Northwest Power Planning Council). 1989. Snake River subbasin salmon and steelhead plan. NWPPC, Portland, Oregon.

ODFW (Oregon Department of Fish and Wildlife). 1998a. Briefing paper – Lower Columbia River chinook ESU. ODFW, Portland. October 13.

ODFW (Oregon Department of Fish and Wildlife). 1998b. Memorandum re: harvest rates for Willamette spring chinooks, to J. Martin from S. Sharr, ODFW, Portland. September 30.

ODFW (Oregon Department of Fish and Wildlife). 1998c. Oregon wild fish management policy. ODFW, Portland.

ODFW (Oregon Department of Fish and Wildlife). 1998d. Spring chinook chapters – Willamette basin fish management plan. ODFW, Portland. March.

ODFW (Oregon Department of Fish and Wildlife) and WDFW (Washington Department of Fish and Wildlife). 1995. Status report, Columbia River fish runs and fisheries, 1938-94. ODFW, Portland, and WDFW, Olympia.

ODFW (Oregon Department of Fish and Wildlife) and WDFW (Washington Department of Fish and Wildlife). 1998. Status report, Columbia River fish runs and fisheries, 1938-1997. ODFW, Portland, and WDFW, Olympia.

ODFW (Oregon Department of Fish and Wildlife) and WDFW (Washington Department of Fish and Wildlife). 1999. Excel spreadsheet: wasurvey.xls. E-mail to National Marine Fisheries Service, Hydro Program, Portland, Oregon, from ODFW, Clackamas, and WDFW, Olympia. December 13.

ODFW (Oregon Department of Fish and Wildlife) and WDFW (Washington Department of Fish and Wildlife). 2000. Joint staff report concerning the 2000 in-river commercial harvest of Columbia River fall chinook salmon, summer steelhead, coho salmon, and sturgeon. ODFW and WDFW, Joint Columbia River Management Staff. July 13.

ODFW (Oregon Department of Fish and Wildlife), WDFW (Washington Department of Fish and Wildlife), and USFWS (U.S. Fish and Wildlife Service). 1999. Fall chinook and chum spawning in the mainstem Columbia below Bonneville Dam. Fact sheet for meeting of Fish Passage Advisory Committee, Columbia Basin Fish and Wildlife Authority, Portland, Oregon. ODFW, Portland, WDFW, Olympia, and USFWS, Portland. August 30.

Olson, F. W., and V. Kaczynski. 1980. Survival of downstream migrant coho salmon and steelhead through bulb turbines. CH2M Hill to Public Utility District No. 1 of Chelan County, Washington.

OWRD (Oregon Water Resources Department). 1993. Memorandum re: weak stocks and water supply conflicts, to D. Moscowitz et al. from T. Kline and B. Fuji, OWRD, Salem. September 17.

Park, D. L. 1969. Seasonal changes in downstream migration of age-group 0 chinook salmon in the upper Columbia River. Transactions of the American Fisheries Society 98:315-317.

Park, D. L., and G. M. Matthews. 1982. Evaluation of transportation and related research, 1982. Interim Research Report of National Marine Fisheries Service, Northwest and Alaska Fisheries Center, Coastal Zone and Estuarine Studies Division, Seattle, Washington, to U.S. Army Corps of Engineers.

Park, D., G. Matthews, J. Smith, T. Ruehle, J. Harmon, and S. Achord. 1984. Evaluation of transportation of juvenile salmonids and related research on the Columbia and Snake Rivers, 1983. National Marine Fisheries Service, Seattle, Washington, to U.S. Army Corps of Engineers, Northwest Pacific Division, Portland, Oregon.

Peery, C. 1998. Fax re: passage times at Snake River dams, to J. Ceballos, NMFS, from C. Peery, Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow. April 9.

Peters, C. N, and D. Marmorek, editors. 2000. PATH: preliminary evaluation of the learning opportunities and biological consequences of monitoring and experimental management actions. ESSA Technologies, Ltd., Vancouver, B.C. April 11.

Peters, C. N, D. R. Marmorek, and I. Parnell, editors. 1999. Plan for analyzing and testing hypotheses (PATH): decision analysis report for Snake River fall chinook. ESSA Technologies Ltd., Vancouver, B.C.

Petrosky, C. E. 1992. Analysis of flow and velocity effects: smolt survival and adult returns of wild spring and summer chinook. Idaho Department of Fish and Game, Chinook Smolt Workshop, Draft Summary, Boise, Idaho.

Petrosky, C., and H. Schaller. 1992. A comparison of productivities for Snake River and lower Columbia River spring and summer chinook stocks. Proceedings of 1992 northeast Pacific chinook and coho workshop, salmon management in the 21st century: recovering stocks in decline. Idaho Chapter of the American Fisheries Society, Boise.

PFMC (Pacific Fishery Management Council). 1998a. Amendment 8 to coastal pelagic species fishery management plan. PFMC, Portland, Oregon. December.

PFMC (Pacific Fishery Management Council). 1998b. Final environmental assessment: regulatory review for Amendment 11 to Pacific Coast groundfish fishery management plan. PFMC, Portland, Oregon.

Phelps, S. R., L. L. LeClair, S. Young, and H. L. Blankenship. 1994. Genetic diversity patterns of chum salmon in the Pacific Northwest. Canadian Journal of Fisheries and Aquatic Sciences 51(Suppl. 1):65-83.

Phillips, J. B. 1964. Life history studies on ten species of rockfish. California Department of Fish and Game, Fish Bulletin 126.

Ploskey, G. R., and eight others. 1999. Hydroacoustic evaluation of juvenile salmon passage at The Dalles Dam, 1999. U.S. Army Corps of Engineers Technical Report.

Poe, T. P., H. C. Hansel, S. Vigg, D. E. Palmer, and L. A. Prendergast. 1991. Feeding of predaceous fishes on out-migrating juvenile salmonids in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:405-420.

Poe, T. P., M. G. Mesa, R. S. Shively, and R. D. Peters. 1994. Development of biological criteria for siting and operation of juvenile bypass systems: implications for protecting juvenile salmonids from predation. Pages 169-176 *in* Proceedings of symposium on fish passage responsibility and technology, American Fisheries Society Annual Meeting, 1993, Portland, Oregon.

Quigley, T. M., and S. J. Arbelbide, editors. 1997. An assessment of ecosystem components in the interior Columbia River basin and portions of the Klamath and Great basins. Volume 3 *in* T. M. Quigley, editor. The interior Columbia basin ecosystem management project: scientific assessment, 4 volumes. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-405, Portland, Oregon.

Raymond, H. L. 1968. Migration rates of yearling chinook salmon in relation to flows and impoundments in the Columbia and Snake rivers. Transactions of the American Fisheries Society 97:356-359.

Raymond, H. L. 1969. Effect of John Day reservoir on the migration rate of juvenile chinook salmon and steelhead in the Columbia River. Transactions of the American Fisheries Society 98:513-514.

Raymond, H. L. 1979. Effects of dams and impoundments on migrations of juvenile chinook salmon and steelhead from the Snake River, 1966 to 1975. Transactions of the American Fisheries Society 108:505-529.

Raymond, H. L. 1988. Effects of hydroelectric development and fisheries enhancement on spring and summer chinook salmon and steelhead in the Columbia River basin. North American Journal of Fisheries Management 8:1-23.

Reimers, P. E., and R. E. Loeffel. 1967. The length of residence of juvenile fall chinook salmon in selected Columbia River tributaries. Fish Commission of Oregon 13:5-19.

Reisenbichler, R. R., J. D. McIntyre, M. F. Solazzi, and S. W. Landino. 1992. Genetic variation in steelhead of Oregon and northern California. Transactions of the American Fisheries Society 121:158-162.

Rich, W. H. 1920. Early history and seaward migration of chinook salmon in the Columbia and Sacramento rivers. Bulletin of the U.S. Bureau of Fisheries 37:1-74.

Rich, W. H. 1942. The salmon runs of the Columbia River in 1938. Fisheries Bulletin 50:103-147.

Ricker, W. E. 1959. Evidence for environmental and genetic influence on certain characters which distinguish stocks of the Pacific salmons and steelhead trout. Fisheries Research Board of Canada, Biological Station, Nanaimo, B.C.

Rieman, B. E., R. C. Beamesderfer, S. Vigg, and T. P. Poe. 1991. Estimated loss of juvenile salmonids to predation by northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:448-458.

Roby, D. D., D. P. Craig, K. Collis, and S. L. Adamany. 1998. Avian predation on juvenile salmonids in the lower Columbia River. Report to Bonneville Power Administration and U.S. Army Corps of Engineers. Oregon Cooperative Fish and Wildlife Research Unit, Corvallis, and Columbia River Inter-Tribal Fish Commission, Portland, Oregon. September revision.

Roedel, P. M. 1948. Common marine fishes of California. California Department of Fish and Game, Fish Bulletin 68.

Roedel, P. M. 1953. Common ocean fishes of the California coast. California Department of Fish and Game, Fish Bulletin 91.

Ruggerone, G. T. 1986. Consumption of migrating juvenile salmonids by gulls foraging below a Columbia River dam. Transactions of the American Fisheries Society 115:736-742.

Salo, E. O. 1991. Life history of chum salmon, *Oncorhynchus keta*. Pages 231-309 *in* C. Groot and L. Margolis, editors. Pacific salmon life histories. University of British Columbia Press, Vancouver, B.C.

Sandercock, F. K. 1991. Life history of coho salmon (*Oncorhynchus kisutch*). Pages 395-445 *in* C. Groot and L. Margolis, editors. Pacific salmon life histories. University of British Columbia Press, Vancouver, B.C.

Schaller, H. A., C. E. Petrosky, and O. P. Langness. 1999. Contrasting patterns of productivity and survival rates for stream-type chinook salmon (*Oncohynchus tshawytscha*) populations of the Snake and Columbia rivers. Canadian Journal of Aquatic Sciences 56:1031-1045.

Schaller, H. A., C. E. Petrosky, and O. P. Langness. 2000. Reply to Zabel and Williams' comments on "Contrasting patterns of productivity and survival rates for stream-type chinook salmon (*Oncorhynchus tschawytscha*) populations of the Snake and Columbia rivers" by Schaller et al. (1999). Canadian Journal of Fisheries and Aquatic Sciences 57:1742-1746.

Scholz, N. L., N. K. Truelove, B. L. French, B. A. Berejikian, T. P. Quinn, E. Casillas, and T. K. Collier. 2000. Diazinon disrupts antipredator and homing behaviors in chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Aquatic Sciences 57:1911-1918.

Schreck, C. B. H. W. Li, R. C. Jhort, and C. S. Sharpe. 1986. Stock identification of Columbia River chinook salmon and steelhead trout. Final report to Bonneville Power Administration, Portland, Oregon (Project 83-451).

Schuck, M. L. 1992. Observations on the effects of reservoir drawdown on the fishery resource behind Little Goose and Lower Granite dams, March 1992. Washington Department of Fish and Wildlife, Report 92-13, Olympia.

Sherwood, C., D.J.B. Harvey, P. Hamilton, and C. Simenstad. 1990. Historical changes in the Columbia River estuary. Progress in Oceanography 25:271-298.

Shively, R. S., R. A. Tabor, R. D. Nelle, D. B. Jepsen, J. H. Petersen, S. T. Sauter, and T. P. Poe. 1991. System-wide significance of predation on juvenile salmonids in the Columbia and Snake river reservoirs. Bonneville Power Administration, Annual Report, Portland, Oregon.

Sigler, J. W., T. C. Bjornn, and F. H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and coho salmon. Transactions of the American Fisheries Society 113:142-150. *In* T. F. Waters. Sediment in streams – sources, biological effects, and control. American Fisheries Society Monograph 7 (1995), Bethesda, Maryland.

Simenstad, C. A., K. L. Fresh, and E. O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: an unappreciated function. Pages 343-364 *in* V. S. Kennedy, editor. Estuarine comparisons. Academic Press, New York.

Simenstad, C. A., D. A. Jay, and C. R. Sherwood. 1992. Impacts of watershed management on land-margin ecosystems: the Columbia River Estuary as a case study. Pages 266-306 *in* R. Naimen, editor. New perspectives for watershed management: balancing long-term sustainability with cumulative environmental change. Springer-Verlag, New York.

Simenstad, C., L. Small, and C. McIntyre. 1990. Consumption processes and food web structure in the Columbia river estuary. Progress in Oceanography 25:271-298.

Simmons, D. 2000. Excel spreadsheet: Snake River fall chinook, annual adult equivalent exploitation rates (AEQ Catch/[AEQ Catch + Escapement]) adjusted to joint staff estimates of ocean escapement. E-mail. National Marine Fisheries Service, Sustainable Fisheries Division, Seattle, Washington. October 2.

Smith, S. G., W. D. Muir, G. A. Axel, R. W. Zabel, and J. G. Williams. 2000. Survival estimates for the passage of juvenile salmonids through Snake and Columbia River dams and reservoirs. National Marine Fisheries Service to Bonneville Power Administration, BPA Report DOE/BP-17679-1, Portland, Oregon.

Smith, S. G., W. D. Muir, E. E. Hockersmith, S. Achord, M. B. Eppard, T. E. Ruehle, and J. G. Williams. 1998. Survival estimates for the passage of juvenile salmonids through Snake River dams and reservoirs, 1996. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington, to Bonneville Power Administration, Portland, Oregon.

Spence, B. C., G. A. Lomnicky, R. M. Hughes, and R. P. Novitzki. 1996. An ecosystem approach to salmonid conservation. ManTech Environmental Research Services, Inc., Corvallis, Oregon, to National Marine Fisheries Service, Habitat Conservation Division, Portland, Oregon (Project TR-4501-96-6057).

Spurgeon, W., and 16 coauthors. 1997. Juvenile fish transportation program. U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

Stanford, J. A., and J. V. Ward. 1992. Management of aquatic resources in large catchments: recognizing interactions between ecosystem connectivity and environmental disturbance. Pages 91-124 *in* R. J. Naiman, editor. Watershed management: balancing sustainability and environmental change. Springer-Verlag, New York.

Steel, E. A. 1999. In-stream factors affecting juvenile chinook salmon migration. Doctoral dissertation. University of Washington, Seattle.

Steig, T. W. 1994. Review of spring and summer spill effectiveness for juvenile salmon and steelhead at various Columbia and Snake river dams, 1983-1992. Thirteenth Annual Symposium of the North American Lake Management Society, Seattle, Washington, November 29 – December 4, 1993. Lake and Reservoir Management 9(1):154-162.

Steig, T. W., and W. R. Johnson. 1986. Hydroacoustic assessment of downstream migrating salmonids at The Dalles Dam in spring and summer 1985. Report to Bonneville Power Administration, Portland, Oregon.

Steigenberger, L. W., and P. A. Larkin. 1974. Feeding activity and rates of digestion of northern squawfish (*Ptychocheilus oregonensis*). Journal of the Fisheries Research Board of Canada 31:411-420.

Sullivan, R., L. Johnson, and T. H. Schadt. 1986. Hydroacoustic evaluation of downstream migrating salmonids at Ice Harbor Dam in spring 1986. Draft Final Report of Parametrix, Bellevue, Washington, to U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

Tabor, R. A., R. S. Shively, and T. P. Poe. 1993. Predation of juvenile salmonids by smallmouth bass and northern squawfish in the Columbia River near Richland, Washington. North American Journal of Fisheries Management 13:831-838.

Thomas, D. W. 1981. Historical analysis of the Columbia River estuary: an ecological approach. Draft Report to Columbia River Estuary Study Taskforce.

Tinus, E. 2000. Pre-1971 abundance for index stocks. Excel spreadsheet \svr99_1_12_2000.xls. Oregon Department of Fish and Wildlife, Portland. January 12.

Turner, A. R., J. R. Kuskie, and K. E. Kostow. 1983. Evaluation of adult fish passage at Little Goose and Lower Granite dams, 1981. U.S. Army Corps of Engineers, Portland District, Portland, Oregon.

Turner, A. R., J. R. Kuskie, and K. E. Kostow. 1984. Evaluations of adult fish passage at Ice Harbor and Lower Monumental dams, 1982. U.S. Army Corps of Engineers, Portland District, Portland, Oregon.

Turner C. H., and J. C. Sexsmith. 1967. Marine baits of California. California Department of Fish and Game, Sacramento.

USFWS (U.S. Fish and Wildlife Service). 1995. Letter re: review of supplemental biological assessment for operation of Federal Columbia River Power System, to Maj. Gen. E. J. Harrell, U.S. Army Corps of Engineers, from USFWS, Portland, Oregon. March 1.

USFWS (U.S. Fish and Wildlife Service). 1999. Fish and Wildlife Coordination Act report. Appendix M *in* U.S. Army Corps of Engineers, Lower Snake River juvenile salmon migration feasibility report/environmental impact statement. Corps, Walla Walla District, Walla Walla, Washington.

USFWS (U.S. Fish and Wildlife Service). 2000a. Biological opinion: effects of listed species from operations of the Federal Columbia River Power System. USFWS, regions 1 and 6, Draft Report. July 27.

USFWS (U.S. Fish and Wildlife Service). 2000b. Presentation on Ives Island studies. Handout for meeting with fisheries comanagers at National Marine Fisheries Service, Portland, Oregon. USFWS, Columbia River Fisheries Program Office, Vancouver, Washington. February 16.

Van Hyning, J. M. 1973. Factors affecting the abundance of fall chinook salmon in the Columbia River. Research Report for Fisheries Commission of Oregon 4:3-87.

Vigg, A., and C. C. Burley. 1991. Temperature dependent maximum daily consumption of juvenile salmonids by northern squawfish (*Ptchocheilus oregonensis*) from the Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 48:2491-2498.

Vigg, S., T. P. Poe, L.A. Prendergast, and H. C. Hansel. 1991. Rates of consumption of juvenile salmonids and alternate prey fish by northern squawfish, walleyes, smallmouth bass, and channel catfish in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:421-438.

Vinyard, G. L., and W. J. O'Brien. 1976. Effects of light and turbidity on the reactive distance of bluegill (*Lepomis macrochirus*). Journal of the Fisheries Research Board of Canada 33:2845-2849.

Walford, L. A. 1931. Handbook of common commercial and game fishes of California. California Division of Fish and Game, Bureau of Commercial Fisheries, Fish Bulletin 28.

Waples, R. S. 1999. Dispelling some myths about hatcheries. Fisheries 24(2):12-21.

Waples, R. 2000a. Memorandum re: natural spawning hatchery fish, to B. Brown from National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. July 7.

Waples, R. 2000b. Preliminary reaction to comments. E-mail to C. Toole and M. McClure from National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. October 30.

Waples, R. S., O. W. Johnson, and R. P. Jones, Jr. 1991. Status review for Snake River sockeye salmon. National Marine Fisheries Service, Northwest Fisheries Science Center, NOAA Technical Memorandum NMFS F/NWC-195, Seattle, Washington.

Ward, D. L., J. H. Peterson, and J. J. Loch. 1995. Index of predation on juvenile salmonids by northern squawfish in the lower and middle Columbia River and in the lower Snake River. Transactions of the American Fisheries Society 124:321-334.

Waring, C .P., and A. Moore. 1997. Sublethal effects of a carbamate pesticide on pheromonal mediated endocrine function in mature male Atlantic salmon (*Salmo salar L.*) parr. Fish Physiology and Biochemistry 17:203-211.

Waters, T. F. 1995. Sediment in streams: sources, biological effects, and control. American Fisheries Society Monograph 7, Bethesda, Maryland.

WDFW (Washington Department of Fish and Wildlife), ODFW (Oregon Department of Fish and Wildlife), IDFG (Idaho Department of Fish and Game), and CRITFC (Columbia River Inter-Tribal Fish Commission). 1995. Spill and 1995 risk management. Olympia, Boise, and Portland.

WDF (Washington Department of Fisheries), WDW (Washington Department of Wildlife), and WWTIT (Western Washington Treaty Indian Tribes). 1993. Washington state salmon and steelhead stock inventory (SASSI), 1992. WDF, WDW, and WWTIT, Olympia.

Weatherley, A. H., and H. S. Gill. 1995. Growth. Pages 103-149 *in* C. Groot, L. Margolis, and W. C. Clarke, editors. Physiological ecology of Pacific salmon. University of British Columbia Press, Vancouver, B.C.

Weitkamp, D. E., and M. Katz. 1980. A review of dissolved gas supersaturation literature. Transactions of the American Fisheries Society 109:659-702.

Weitkamp, D. E., J. P. Michaud, and J. G. Osborn. 1986. Downstream migrant estimates Rocky Reach and Rock Island dams. Parametrix, Inc., for Chelan County PUD, Wenatchee, Washington.

Weitkamp, L. A. 1994. A review of the effects of dams on the Columbia River estuarine environment, with special reference to salmonids. National Marine Fisheries Service, Northwest Fisheries Science Center, Coastal Zone Estuary Studies Division, Seattle, Washington, to Bonneville Power Administration, Portland, Oregon.

Whitney, R. R., L. Calvin, M. Erho, and C. Coutant. 1997. Downstream passage for salmon at hydroelectric projects in the Columbia River basin: development, installation, and evaluation. U.S. Department of Energy, Northwest Power Planning Council, Report 97-15, Portland, Oregon.

Whitt, C. R. 1954. The age, growth, and migration of steelhead trout in the Clearwater River, Idaho. Master's thesis. University of Idaho, Moscow.

Williams, J. G., S. S. Smith, and W. D. Muir. In review. Survival estimates for downstream migrant yearling juvenile salmonids through the Snake and Columbia River hydropower system, 1960-1980 and 1993-1999. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. Submitted to North American Journal of Fisheries Management.

Wilson, P. H. 2000. Comments on BiOp Appendix C. E-mail to C. Toole, National Marine Fisheries Service. October 2.

Wood, C. C. 1987. Predation of juvenile Pacific salmon by the common merganser (*Mergus merganser*) on eastern Vancouver Island. Part 1: predation during the seaward migration. Canadian Journal of Fisheries and Aquatic Sciences 44:941-949.

Wood, D. 2000. Memorandum to M. Dehart, Fish Passage Center, Portland, Oregon. February 11.

Yearsley, J. 1999. Columbia River temperature assessment: simulation models. U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

Zabel, R. W., and J. G. Williams. 2000. Comments on "Contrasting patterns of productivity and survival rates for stream-type chinook salmon (*Oncorhynchus tschawytscha*) populations of the Snake and Columbia rivers" by Schaller et al. (1999). Canadian Journal of Fisheries and Aquatic Sciences 57:1739-1741.

Zaret, T. M. 1979. Predation in freshwater communities. Pages 135-143 *in* H. Clepper, editor. Predator-prey systems in fisheries management. Sport Fishing Institute, Washington, D.C.

Zaugg, W. S. 1981. Relationships between smolt indices and migration in controlled and natural environments. Pages 173-183 *in* E. L. Brannon and E. O. Salo, editors. Proceedings of the salmon and trout migratory behavior symposium. University of Washington, Seattle.

Zaugg, W. S. 1981. Advanced photoperiod and water temperature effects on gill Na+-K+ ATPase adenosine triphosphate activity and migration of juvenile steelhead (*Salmo gairdneri*). Canadian Journal of Fisheries and Aquatic Sciences 38:758-764.

Zaugg, W. S. 1989. Migratory behavior of underyearling *Oncorhynchus tshawytscha* and survival to adulthood related to prerelease gill (Na+ - K+)-ATPase development. Aquaculture 82:339-353.

Zaugg, W. S., and H. H. Wagner. 1973. Gill ATPase activity related to parr-smolt transformation and migration in steelhead trout (*Salmo gairdneri*): influence of photoperiod and temperature. Comparative Biochemical Physiology 45:955-965.